COMPLICATIONS OF NASOTRACHEAL INTUBATION IN NEONATES, INFANTS AND CHILDREN: A REVIEW OF 4 YEARS' EXPERIENCE IN A CHILDREN'S HOSPITAL

A. E. BLACK, D. J. HATCH AND N. NAUTH-MISIR

SUMMARY

A computerized database was set up to study the incidence and outcome of complications of nasotracheal intubation in a paediatric hospital. We studied 2953 intensive care admissions over a 4-yr period. The overall complication rate was 8%. Accidental extubation and tube blockage were the most frequent events, accounting for a mean of 3.5% and 2.6% of the complications per year, respectively. Complications were more common in smaller children and there were differences between fields of intensive care. None of the complications was fatal or resulted in serious sequelae. None of the children in the study showed clinical symptoms of acquired subglottic stenosis before discharge from hospital, and none has been readmitted for this condition subsequently.

KEY WORDS

Prolonged tracheal intubation was recommended as a useful alternative to tracheostomy more than 20 yr ago [1, 2] and, since then, has been the main method of airway support during intensive care in children.

The most important complications noted in the early reports were tube displacement, tube obstruction and post-extubation stridor [3], leaving 2-4% of patients with intractable subglottic stenosis [4-7]. Fatalities were described from each of these complications.

The advent of computerized databases has allowed comprehensive data collection, retrieval and analysis to be performed. We therefore decided to design a prospective database to allow analysis of all intubation-related complications. This paper describes the reported complications in 2953 intensive care admissions requiring periods of tracheal intubation in patients in the first 4 yr of data collection, from January 1985 to December 1988.

METHODS

A basic data sheet has been used for each intensive care patient for many years. This sheet was modified to include all complications of tracheal intubation and the reasons for reintubation when this occurred (table I). This information was transferred to a database using the Data Base II compatible software program, “Friday!” set up on a North Star Advantage computer with a 5-megabyte hard disc. Each year’s results were analysed separately and then combined.

RESULTS

In the 4-yr study period, a total of 2791 intensive care patients required tracheal intubation (table II). The nasal route was used in all children aged up to the early teens, using the method of fixation described by Reid and Tunstall [8]. In children requiring intubation for more than 1 week, tubes have been changed routinely every 10-14 days, although it is recognized that many regard this as unnecessary. Forty-seven patients in 1985, 25 in

---


*Present address, for correspondence: 7263 Pine Street, Upper Darby, Pa 19802, U.S.A.
### Table I. Details of respiratory data sheet and definitions

<table>
<thead>
<tr>
<th>Front</th>
<th>Back</th>
</tr>
</thead>
</table>
| **NAME** | **Respiratory Score:** 1 2 3 4  
D. O. B.  
Hosp. No.  
Ward:  
Wt:  |
| **Diagnosis:**  
Intubated on arrival? Y/N (indicate size & type)  
Cole: Plastic Nasal: Plastic Oral: Other: |
| 1st GOS Tube: Age: years mths days hours  
Date: Time: Size: Length: Reason: Extubation Date & Time:  |
| 1st  
2nd  
3rd  
4th |
| **Reasons for intubation** | **Respiratory score** | **Complications** |
| A = Failed extubation  
B = Blocked tubes  
C = Accidental extubation  
D = Tube too long  
E = Tube too short  
F = No leak  
G = Excessive leak  
H = Stridor on extubation  
N = None  
R = Routine  |
| 1 = IPPV at any time  
2 = Spontaneous ventilation  
3 = CPAP only  
4 = Prong only  |
| B = Blocked tube  
C = Accidental extubation  
H = Stridor on extubation  
M = Nasal ulceration  
N = None  
T = Bronchial intubation  
V = Disconnection  |
NASOTRACHEAL INTUBATION

TABLE II. Number of intubations and patients

<table>
<thead>
<tr>
<th>Year</th>
<th>1985</th>
<th>1986</th>
<th>1987</th>
<th>1988</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICU admissions requiring intubation</td>
<td>776</td>
<td>625</td>
<td>725</td>
<td>827</td>
<td>2953</td>
</tr>
<tr>
<td>Patients</td>
<td>729</td>
<td>600</td>
<td>690</td>
<td>772</td>
<td>2791</td>
</tr>
<tr>
<td>Total intubations</td>
<td>944</td>
<td>842</td>
<td>917</td>
<td>831</td>
<td>3534</td>
</tr>
</tbody>
</table>

TABLE III. Number of intubations per admission 1985–1988

<table>
<thead>
<tr>
<th>No. of intubations</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>&gt; 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent of children</td>
<td>80.5</td>
<td>14.4</td>
<td>2.7</td>
<td>1.6</td>
<td>0.8</td>
</tr>
</tbody>
</table>

TABLE IV. Age distribution on admission 1985–1988

<table>
<thead>
<tr>
<th>Age</th>
<th>No.</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 28 days</td>
<td>749</td>
<td>25</td>
</tr>
<tr>
<td>28 days – 1 yr</td>
<td>914</td>
<td>31</td>
</tr>
<tr>
<td>1–5 yr</td>
<td>729</td>
<td>25</td>
</tr>
<tr>
<td>5–10 yr</td>
<td>321</td>
<td>11</td>
</tr>
<tr>
<td>&gt; 10 yr</td>
<td>240</td>
<td>8</td>
</tr>
</tbody>
</table>

TABLE V. Duration of intubation

<table>
<thead>
<tr>
<th>Duration of intubation (days)</th>
<th>&lt; 2</th>
<th>2–7</th>
<th>7–14</th>
<th>&gt; 14</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent of children</td>
<td>51</td>
<td>29</td>
<td>11</td>
<td>9</td>
</tr>
</tbody>
</table>

1986, 35 in 1987 and 55 in 1988 had a second admission to one of the intensive care wards and required further periods of intubation, so that a total of 2953 data sheets were analysed. The majority of children (80%) underwent intubation only once on each admission; 14.4% underwent intubation twice and 5.1% on more than two occasions (table III). The maximum number of intubations in any admission was eight. The ages of the patients at the time of initial intubation on each admission are shown in table IV. Ages ranged from within 4 h of birth to 19 yr, with 25% within the neonatal period and 56% infants younger than 1 yr. More than 80% of patients were younger than 5 yr. Four hundred and forty-three patients died whilst receiving intensive care, an overall mortality of 15.9%.

The duration of intubation is shown in table V and distribution of patients between the four main intensive care wards in table VI. More than 50% of all patients underwent intubation for less than 48 h and 20% for more than 7 days. The longest period of intubation on any admission was 90 days. Although the majority of admissions (53%) were cardiac, the duration of intubation tended to be shorter in these children, who occupied 46% of the total intubation days (table VII). Patients admitted to the neonatal surgical intensive care ward tended to require intubation of the trachea for longer periods than those on the other intensive care wards (12% of admissions occupying 21% of the intubation days).

During the period of the study 239 complications were reported, with an overall complication rate of 8% (table VIII). None of these complications was fatal or caused cardiac arrest, and no long term sequelae were identified in any patient.

The commonest complications were accidental extubation and tube blockage, requiring immediate re-intubation in 75% and 90% of patients in whom they occurred, respectively. Both of these complications were more frequent in the younger patients. Eighty per cent of the accidental extubations occurred in infants aged less than 1 yr and 80% of the blockages occurred in tubes of i.d. 3.5 mm or less. Stridor occurred after extubation in 44 subjects, but was severe enough to require a further short period of intubation in only 21 patients. In no case did it lead to the development of any long term sequelae.
TABLE VIII. Complications

<table>
<thead>
<tr>
<th></th>
<th>1985</th>
<th>1986</th>
<th>1987</th>
<th>1988</th>
<th>Total</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accidental extubation</td>
<td>23</td>
<td>19</td>
<td>22</td>
<td>41</td>
<td>105</td>
<td>3.5</td>
</tr>
<tr>
<td>Tube blockage</td>
<td>13</td>
<td>22</td>
<td>23</td>
<td>19</td>
<td>77</td>
<td>2.6</td>
</tr>
<tr>
<td>Stridor</td>
<td>14</td>
<td>8</td>
<td>11</td>
<td>11</td>
<td>44</td>
<td>1.5</td>
</tr>
<tr>
<td>Nasal ulceration</td>
<td>4</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>9</td>
<td>0.3</td>
</tr>
<tr>
<td>Bronchial intubation</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>0.1</td>
</tr>
<tr>
<td>Total</td>
<td>54</td>
<td>49</td>
<td>60</td>
<td>76</td>
<td>239</td>
<td>8.08</td>
</tr>
<tr>
<td>%</td>
<td>6.9</td>
<td>7.8</td>
<td>8.2</td>
<td>9.2</td>
<td>8.08</td>
<td></td>
</tr>
</tbody>
</table>

TABLE IX. Laryngeal pathology causing stridor, 1985–1988

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>No. patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Haemangioma with tracheal involvement</td>
<td>2</td>
</tr>
<tr>
<td>Tracheomalacia</td>
<td>3</td>
</tr>
<tr>
<td>Congenital subglottic stenosis (Down's syndrome in one)</td>
<td>3</td>
</tr>
<tr>
<td>Croup</td>
<td>1</td>
</tr>
<tr>
<td>Tracheo–oesophageal fistula</td>
<td>2</td>
</tr>
<tr>
<td>Bilateral vocal cord palsy</td>
<td>1</td>
</tr>
<tr>
<td>Vater syndrome</td>
<td>1</td>
</tr>
<tr>
<td>Laryngeal tuberculosis</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>14</td>
</tr>
</tbody>
</table>

of clinical symptoms of acquired subglottic stenosis before discharge. Pre-existing laryngeal pathology, causing stridor was present in 14 patients (table IX). Bronchial intubation was reported in four patients and nasal ulceration in nine. One hundred and eleven patients (4%) required tracheotomy during their period of intensive care.

DISCUSSION

The advantages of long term nasotracheal intubation in infants and small children as an alternative to tracheostomy have been recognized for many years [1, 2]. The main complications described in the early series were accidental extubation, tube blockage and subglottic stenosis, all of which caused fatalities [3]. Other less serious complications have been reported also [9]. In an early study from this hospital [7], the overall mortality was 3.6%. In that series, accidental extubation occurred in three of 167 intubations (one death) and tube obstruction occurred in eight (four deaths). Subglottic stenosis occurred in three cases (one death).

The complication rate in the present study was 8%, varying between 6.9% and 9.2% annually during the study. In contrast with the earlier series, no complication resulted in death or other serious sequelae.

Accidental extubation and tube obstruction remained the commonest complications. It is difficult to compare the incidence of accidental extubation or tube blockage in this series with that reported from this hospital in 1968 [7], as the incidence related to days of intubation was not reported in the earlier paper. However, both these complications still occur regularly. Although accidental extubation is less likely to occur when neuromuscular blocking drugs are used, the risk of hypoxic sequelae is increased. The absence of mortality or serious morbidity from each complication in this series probably results from the infrequent use of neuromuscular blocking drugs and improvements in patient monitoring. There have been no cases of clinically significant subglottic stenosis produced within the hospital since the policy was adopted of ensuring that a slight leak occurs around the tube with the application of 25 cm of pressure to the airway [10], although stridor did occur after extubation in 1.5% of patients.

Accidental extubation

While individual tube lengths should be determined at intubation by direct vision, and confirmed by x-ray, a formula based on actual tube lengths recorded in this study (internal diameter x 3 + 2 cm) has proved useful [11]. However, the majority of tubes which were displaced accidentally were of adequate length as judged by the formula quoted above; in four patients they were noted to be a little long. Few patients were paralysed, so that if accidental extubation occurred, spontaneous ventilation continued, reducing the risk of hypoxic damage. This complication, often occurring during weaning from ventilatory support when the patients did not require re-intubation, was recognized rapidly. In
five of the patients who suffered accidental extubation, the tube had been noted previously on x-ray to be short. However, because the patient was thought to be nearly ready to undergo extubation of the trachea, the decision had been made not to change it for a longer one.

Forty-two (40%) of the patients who exhibited accidental extubation were neonates, and 88 (84%) were less than 1 yr old. This complication occurred in some infants on more than one occasion. Accidental extubation was seen in 3.4.9% of admissions per annum in this study; this appeared to increase in 1988. There was no obvious reason for this increase, which occurred mainly in the cardiac unit. On average, accidental extubation occurred only once every 167 intubation days. The accidental extubation rate was higher on the respiratory/medical ward (every 125 intubation days) than on the other wards (every 179 days on the cardiac ward and 185 days on the neonatal surgical ward). This may be partly because of the more frequent use of infusions of opioids in postoperative patients. There was only one accidental extubation on the neurosurgical ward, where the use of neuromuscular blocking agents was more common, but this ward accounted for only 2% of total intubation days.

Accidental extubation is a risk which is particularly likely to occur during weaning from the ventilator.

Tube blockage

The incidence of tube blockage varied between 1.6% and 3.5% (mean 2.6%), despite the use of high humidity and the regular instillation of normal saline down the tube followed by suction. In more than 90% of patients, the blockage necessitated immediate replacement of the tube. Over 80% of blockages occurred with a tube of 3.5 mm diameter or less. Meticulous nursing care is required if these small tubes are to be kept patent, and it is important that the suction catheter is passed through the tube completely. Therefore, its length should be noted. It is possible that the reluctance of staff to disturb the smallest, sickest infants by too frequent suctioning may have been responsible in part for the higher incidence of tube blockage in this group. The incidence of blockage was greater in the respiratory/medical ward (every 156 days) than in other wards (every 179 days on the cardiac ward and 218 days on the neonatal surgical ward), probably because these patients tended to have more secretions. In 1985, some patients were still being nursed in areas such as the infectious disease ward, outside the main intensive care areas of the hospital, partly because the relevant nursing skills were thought to be most appropriate for individual cases on such wards, but partly because of the reluctance of individual consultants to refer patients to the intensive therapy wards. The incidence of tube blockage occurred twice as frequently in outside wards, and provided useful factual evidence with which to convince the hospital to prohibit the use of artificial ventilation outside designated intensive therapy areas. There were no tube blockages on the neurosurgical ward.

Stridor on extubation

Although this complication occurred in 44 patients, it was severe enough to require re-intubation in only 21—less than 1% of the total series. This is in contrast with early reports which described an incidence of post-intubation stridor of 4–10% [3, 12] and an incidence of subglottic stenosis of 2–4% [4–7]. This improvement probably resulted from the fact that the tube is always small enough to allow a slight leak of air around it when positive pressure is applied [13]. In the 3-yr period, only six tubes had to be changed because there was no leak around them, although in the same period 58 tubes had to be changed because the leak was excessive. This suggests that, at least in this department, Stocks' message has been taken seriously.

Abbott [3] showed that sub-clinical post-intubation laryngeal damage could be identified at laryngoscopy, even in patients without stridor, but the clinical significance of this finding is debatable. None of the patients who were admitted on subsequent occasions and required tracheal intubation was noted to have evidence of subglottic narrowing; however, elective post-intubation laryngoscopy was not felt justifiable in patients without symptoms.

The number of patients requiring re-intubation for stridor has declined progressively during the period of the study, from 10 in 1985 to two in 1988. None of the patients who developed stridor was a neonate, although 11 (25%) were younger than 1 yr. Fourteen (32%) had pre-existing laryngeal pathology (table IX), two with haemangiomata involving the airway requiring tracheotomy. Ten patients, including two of those with laryngeal pathology, had been intubated at the referring hospital before transfer to Great
Ormond Street, and in two patients a Cole pattern tube, which is known to cause laryngeal damage [14], had been used. The incidence of stridor in patients without laryngeal pathology, whose trachea had not been intubated before transfer, was 50% of the overall incidence.

The average duration of intubation in patients who developed stridor was 6.5 days, varying between 12 h and 29 days. There appeared to be no relationship between duration of intubation or repeated intubation and the incidence of stridor.

Nasal ulceration

There were six patients with marked nasal ulceration over the 3-yr period, although lesser degrees of temporary nasal erythema were more common. This complication may have been under-reported. The effect of the ventilator tubing pulling the Tunstall frame upwards against the nares was the main cause; other relevant factors were the presence of sepsis, hypotensive periods, or both, when peripheral perfusion may have been compromised. Careful fixation of the connector away from the nose and protection of the alae with stoma adhesive or foam-backed dressing may reduce the incidence of this complication.

Bronchial intubation

The initial tube was too long in 59 patients, although in only four did bronchial intubation occur. One of these was a 1.6-kg neonate with bronchopulmonary dysplasia in whom a tube of 10 cm length had been used. A substitute tube of 9 cm length came out accidentally 21 days later, demonstrating the fine balance between a tube being too long or too short in small infants.

Multiple complications

Multiple complications occurred in several children, most of whom were infants. The commonest association was blockage of the tube with accidental extubation. This probably reflects the fact that both these complications are more common in this age group.

Indications for tracheotomy

One hundred and eleven patients in this study required tracheotomy (4%). The majority (63) had pre-existing upper airway problems, and the remainder required very long term ventilatory support either for medical problems or following surgical repair of such conditions as congenital diaphragmatic hernia with severe pulmonary hypoplasia, or with diaphragmatic paralysis following cardiac surgery. Othersen [15] considered that there was an overdependence on long term nasotracheal intubation in children and advocated early tracheotomy. However, this study shows that long term tracheal intubation can be managed with an acceptably low incidence of complications, and that tracheotomy has virtually no role in patients without pre-existing upper airway pathology for the first 3–6 weeks. If, after this time or even earlier, it is clear that there is no likelihood of an end to the period of airway support in the near future, tracheotomy should be considered, as it has considerable advantages for very long term airway support, particularly in terms of the emotional development of the child. Tracheotomy has been shown previously to be a relatively safe procedure in infants and young children [16, 17]. There were no deaths in any of our patients who required tracheotomy. However, complications have been reported frequently, especially in young infants and patients in whom the pathology is initially infective [18, 19].

Implications for future patient care

Computerized monitoring of complication rates over the past 4 years has had several benefits. It has ensured that all patient data sheets are stored with 100% retrieval, thus allowing continuity of care both on a day-to-day basis and for longer term follow-up. Information is available rapidly in the event of repeated admissions, and the close monitoring of both morbidity and mortality is encouraged, together with the assessment of the effects of changes in management. Internal audit of the complication rates year by year provides an incentive to the members of the department to devise ways of trying to minimize their incidence, and permits early monitoring of any sudden increase in complications in any of the main intensive care areas. Data collected in this database are presented regularly at departmental mortality and morbidity meetings, and have generated useful discussions between the physicians and anaesthetists in charge of the intensive therapy units in the hospital.

REFERENCES

Nasotracheal Intubation