

Artificial ventilation in severe pertussis

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SUMMARY A retrospective review was conducted of all children admitted to our intensive care unit over eight years with a diagnosis of pertussis that had been proved on culture. Altogether 789 children were seen as outpatients and inpatients. Twenty four of these children were admitted to the intensive care unit, 13 of whom required ventilatory support; two of the ventilated patients died. Intubation and ventilation were usually started for appreciable apnoea. Most patients requiring support were less than 3 months of age and required intervention within the first 16 days of cough. For these patients ventilation was neither difficult nor prolonged. Coughing spasms were not a problem and intubation and ventilation appeared to attenuate the progress of the disease. The presence of severe bacterial pneumonia associated with difficult ventilation requiring neuromuscular paralysis indicated a poor prognosis. It is suggested that intubation and ventilation can be safely used in very severe pertussis infection and, because of their greater risk of hypoxic damage and death, it should not be reserved as a last resort in critically ill infants.

Pertussis, a major cause of death in third world nations, continues to occur in Western countries because of breakdowns in immunisation.¹ Major outbreaks were reported from the United Kingdom in 1977–8 and 1982–3,² and in Oklahoma in 1983.³ Pertussis often occurs in New South Wales despite an immunisation rate of more than 90%. Death from pertussis continues to occur in Western countries, because of respiratory failure, usually from apnoea rather than from secondary infection or aspiration. It is surprising that little has been written about the treatment of severe pertussis where ventilatory assistance is required.

Only one report discusses ventilation in children with pertussis.⁴ This report suffers from a very low number of proved cases and no details of important aspects of ventilation. Most textbooks give no mention of intubation and ventilation except as a facility that must be available.^{5–8} There is a common assumption that severe coughing spasms would make ventilatory intervention difficult and that such treatment should be avoided if at all possible. We therefore describe our experience from the intensive care unit of a referral teaching hospital with frequent admissions due to pertussis.

Patients and methods

A retrospective review was conducted of children

admitted to the intensive care unit of the Children's Hospital, Camperdown, between January 1978 and March 1986 who had pertussis infection proved on culture. Children were admitted to the intensive care unit with this diagnosis if they were already receiving artificial ventilation or if appreciable apnoea or severe coughing spasms with cyanosis or bradycardia, or both, were present.

The following details were recorded on all patients: age, duration of hospital admission, changes seen on chest radiography, and complications. For ventilated patients the following details were also recorded: indications for tracheal intubation, time stage in the illness when ventilation was required, drugs used to facilitate artificial ventilation, ventilatory pressures required, and total duration of ventilatory assistance. These data were used to review the indications, efficacy, and complications of ventilatory assistance in pertussis.

Results

During the eight year and three month period of the study, there were 789 positive cultures for *Bordetella pertussis* in inpatients and outpatients seen at the hospital. Altogether 324 patients (41%) were admitted to hospital, 24 (7%) of them being admitted to the intensive care unit. Of these 24 children, 13 (54%) required ventilatory support; two (15%)

of the ventilated children died. Only those patients admitted to the intensive care unit are included in the analysis.

Indications for artificial ventilation were: (a) clinically important recurrent apnoea associated with bradycardia and cyanosis in 11 cases; (b) an episode of paroxysmal cough associated with periods of bradycardia over 40 minutes in one case; and (c) elective postoperative ventilation in one case.

Two ventilated patients were atypical and have been excluded from comparison with the non-ventilated group. The first, a 14 month old girl, had respiratory arrest associated with vomiting and aspiration and recovered without deficit after ventilation for one hour. The second, a 12 week old boy with biliary atresia was electively ventilated for 46 hours after a Kasai procedure for biliary atresia. His progress was complicated seven days postoperatively by wound dehiscence associated with paroxysmal cough but he had subsequent good recovery. One non-ventilated patient was atypical and has been excluded from comparison: this 10 month old infant presented with a clinical appearance consistent with viral bronchiolitis; both *B pertussis* and parainfluenza type III were isolated.

When these three patients are excluded, the average age of admission of the ventilated group was 5.5 weeks (3–11 weeks); the non-ventilated group had an average age of 8.2 weeks (4–14 weeks). The average duration of admission to hospital was 20.5 days (1–42 days) for the ventilated group and

24.2 days (2–70 days) for the non-ventilated group. On discharge, patients had only occasional mild coughing spasms.

All patients presented with typical symptoms of pertussis—that is, paroxysmal cough associated with cyanosis. In contrast to the ventilated group, only one non-ventilated patient had apnoea and only in a single episode. There were, however, no significant differences between the ventilated and non-ventilated groups in terms of duration of illness before admission to the ward, age, results of chest radiography, and duration of admission to the hospital. One ventilated patient had a history of prematurity and one had appreciable underlying heart disease. Apart from three patients further detailed below, chest radiography showed only overdistension of lung fields with or without areas of minor lung collapse.

Ventilation details in those patients requiring artificial ventilation are shown in the table. All patients were ventilated with a pressure-cycled ventilator. Patients were intubated on average at 7.3 days of cough (3–16 days). Duration of intubation was on average 139 hours (2–461 hours); average time of intermittent positive pressure ventilation was 107 hours (2–461 hours); average duration of subsequent continuous positive airways pressure was 32 hours (0–92). Eight patients were not difficult to ventilate. This group required only morphine infusion (20–40 µg/kg/hour) without neuromuscular paralysis and required only standard

Table Details of children with pertussis requiring artificial ventilation

Case No	Age at intubation (weeks)	No of days illness when intubated	Duration of intubation (hours)	Ventilatory pressures (cm H ₂ O) peak/end-expiratory (maximum)	Duration of intermittent positive pressure ventilation (hours)	Duration of continuous positive pressure (hours)	Morphine (infusion or bolus)	Paralysis with pancuronium	Complications
1	6	16	228	40/4	210	18	Infusion	+	Klebsiella pneumonia
2	4	3	174	26/6	126	48	Infusion		
3	3	10	123.5	25/5	49.5	74	Infusion		
4	11	7	24	38/4	24	—	—	+	Died
5	4	7	210	30/5	141	69	Infusion		
6	6	4	68	18/3	68	—	Bolus		
7	4	7	49	25/4	44	5	Bolus		
8	4	7	121	20/5	29	92	—		
9	6	3	2	Not available	2	—	—		
10	6	14	67	25/5	20	47	Infusion		
11	6	5	461	40/6	461	—	Infusion		Died/Klebsiella pneumonia
12*	60	8	9.75	Not available	1	—	—		
13*†	12	20	46.5	20/4	21	25.5	Infusion		
		27	21.5	18/4	16	5.5	Infusion		

*Excluded from comparison with non-ventilated patients.

†Case 13 had two periods of ventilation.

inflation pressures to produce normocarbia. After intubation, coughing spasms did not present a problem and there was a decrease in their severity and frequency. For this group, average time of intubation was 102 hours (2–210), average time of intermittent positive pressure ventilation was 60 hours (2–141); average time of continuous positive pressure airways pressure was 42 hours (0–92). Patients were weaned from ventilation when coughing spasms became infrequent and were not associated with apnoea, cyanosis, or bradycardia.

Three patients were difficult to ventilate, and two of them died. The first was a 6 week old boy whose course was complicated by collapse of his left lung and *Klebsiella septicaemia*. He was intubated for 220 hours with a maximum peak ventilator pressure of 40 cm H₂O, and a fractional inspiratory oxygen (FiO₂) up to 0.8. He received a morphine infusion and was paralysed with pancuronium for 111 hours. The second infant was an 11 week old girl who suffered a respiratory arrest before transfer to hospital; she deteriorated rapidly with severe pulmonary hypertension dying 24 hours after her arrest. Chest radiography showed overdistension and bilateral irregular dense opacities. Postmortem examination showed bilateral pertussis pneumonia. She had been ventilated for 24 hours from the time of respiratory arrest, with maximum settings of 38 cm H₂O, FiO₂ 1.0. She received pancuronium for 9.5 hours. The third infant was a 6 week old girl with tricuspid atresia and compression of left mainstem bronchus. She required ventilation for 461 hours before she died with maximum settings of 40 cm H₂O, FiO₂ 1.0. Postmortem examination showed bilateral *Klebsiella pneumonia*.

All patients received erythromycin to reduce their infectivity. Corticosteroids were not used in any patient. No pathogens were isolated apart from those mentioned.

Discussion

In the United States, pertussis continues to decline as immunisation rates increase. In 1982, only 1895 cases were reported with four deaths; this is a similar mortality rate to that found in our study.⁹ In Australia pertussis appears to be more frequent, this is possibly due to deletion of the 18 month pertussis vaccine from 1979; the vaccine has been recently reinstated because of increasingly frequent pertussis infection in preschool and school age children.

Pertussis remains a dangerous and potentially fatal disease, especially in the young infant.^{10 11} Paroxysmal coughing, apnoea, and vomiting with aspiration may all lead to hypoxia and its sequelae. Pneumonia and lung collapse, though rare, are

other potentially serious lung complications. Accurate death rate statistics are unavailable. Application of a statistical model to analysis of pertussis deaths in the United Kingdom suggested the death rate was probably twice to 10 times that reported on death certificates.² It is reasonable to assume that application of modern paediatric intensive care to seriously ill infants with pertussis could lower the death rate.

In our study the incidence of artificial ventilation may seem high. Children seen at this referral children's hospital, however, are a highly selected population, with a large number sent specifically because of the severity of their illness and the possible need for intensive care.

Supportive care remains the mainstay of treatment for pertussis. Specific treatments such as antibiotics, β agonists, and corticosteroids do not change the course of the disease.^{9 12} Treatment consists of preventing serious hypoxia, and in hospitalised children oxygen is traditionally administered during coughing spasms with a means for ventilatory assistance (bag and mask) close at hand, but it is rarely needed.

In our experience, when the indications for ventilatory assistance applied in other serious respiratory illnesses of infancy are applied to pertussis, a number of infants with pertussis will require ventilatory assistance.

This study examined the results of tracheal intubation and ventilation of children with proved pertussis infection and we concluded that:

- (1) Children requiring intervention are young (less than 3 months old with an average age of 5.5 weeks); intervention instituted for appreciable recurrent apnoea was required within the first 16 days of coughing.
- (2) Mechanical ventilation is not difficult or prolonged in most patients. Only standard ventilatory pressures along with morphine infusion are required for control. Contrary to expectations, coughing spasms are not a problem. This may have been due to effective cough suppression by morphine infusion. It is our impression, however, that intubation and ventilation may attenuate the progress of the disease with a decrease in the frequency and severity of coughing spasms. The need to resort to neuromuscular paralysing agents was infrequent and associated with a poor prognosis.
- (3) Infants requiring ventilatory support had more serious disease but do not have more

prolonged admissions to hospital than non-ventilated patients.

- (4) Complications in ventilated patients are low and overall mortality is low, considering patient selection.

In our study, those patients who did not respond well to ventilation consisted of two children with *Klebsiella pneumoniae* (one with a severe underlying cardiac disease) and another with severe intractable pulmonary hypertension. The last infant had effects from hypoxia secondary to respiratory arrest. It is evident that severe pneumonia associated with difficult ventilation requiring neuromuscular paralysis indicates a poor prognosis. It is of interest that acute viral bronchiolitis in infancy also has a higher death rate where there is pre-existing heart or lung disease.¹³

Despite the common assumption that artificial ventilation in pertussis should be avoided if possible, this report indicates that relatively early intervention in infants with respiratory failure due to pertussis infection is safe and should not be reserved as a last resort.

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