Bacterial tracheitis in children

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We examined the records of 14 patients aged 7 months to 10¼ years who were treated for bacterial tracheitis from May 1982 to December 1987; the management protocol for 13 of the patients included the use of nasotracheal intubation. The infection was caused by *Staphylococcus aureus* in seven, *Haemophilus influenzae* in three, *Branhamella catarrhalis* in one and *Streptococcus pneumoniae* in one. Both *H. influenzae* and *B. catarrhalis* were isolated in another patient, and no organism was found in the remaining patient. In addition to the bacteria, viruses were cultured from the tracheal secretions of two patients. The mean duration of intubation was 7.6 days and of hospital stay 9.2 days. Twelve of the cases occurred during the cold months of the year (October to March). Of the three deaths only one occurred in the pediatric intensive care unit and was due to severe bronchospasm and an air leak that caused bilateral pneumothorax and pneumomediastinum. In one patient subglottic stenosis developed that necessitated tracheostomy. Healing began 5 to 9 days after the onset of symptoms, as demonstrated with the use of repeated fibreoptic bronchoscopy. We found that the airway could be safely managed with the use of a nasotracheal tube. Bronchoscopy helped to confirm the diagnosis, to remove adherent secretions and to monitor the course of the disease. The ventilation tube can be removed after the patient's temperature returns to normal, if there is an air leak around the tube, if the quantity and viscosity of the secretions decrease and if healing is observed at bronchoscopy.

Revue sur dossiers de 14 malades âgés de 7 mois à 10 ans ¼ traités pour trachéite bactérienne de mai 1982 à décembre 1987. Chez tous sauf un le traitement comporte l'intubation nasotrachéale. L'infection est à *Staphylococcus aureus* sept fois, *Haemophilus influenzae* trois fois, *Branhamella catarrhalis* une fois, *Streptococcus pneumoniae* une fois. On trouve la deuxième et la troisième de ces espèces en association une autre fois; chez le malade restant on n'isole aucun germe. Chez deux enfants, en plus des bactéries on trouve des virus. La durée moyenne de l'intubation est de 7,6 jours et celle de l'hopitalisation de 9,2 jours. Douze cas se présentent d'octobre à mars. Des trois décès, un seul est survenu en salle de soins intensifs; dans ce cas il existait un bronchospasme sévère et une fuite d'air ayant déterminé un pneumothorax bilatéral et un pneumomédiastin. Chez un malade la survenue d'une sténose sous-glottique nécessite la trachéostomie. La bronchoscopie avec guide de lumière, pratiquée à répétition, démontre la guérison dans un délai de 5 à 9 jours après le début des symptômes. La sonde nasotrachéale suffit à assurer la perméabilité de la voie aérienne; quant à la bronchoscopie, elle permet d'asseoir le diagnostic, d'aspirer les sécrétions tenaces et de suivre l'évolution. On peut enlever la sonde lorsque la température est normale, s'il y a une fuite d'air autour de la sonde, si les sécrétions se font moins abondantes et moins visqueuses et que la bronchoscopie montre que la guérison est en cours.

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Bacterial tracheitis has been intermittently recognized since at least the 1940s but was rediscovered by Han, Dunbar and Striker[1] in 1979 under the name membranous laryngotracheobronchitis. A month later Jones, Santos and Overall[2] coined the term bacterial tracheitis. Both articles described a severe disease caused by bacterial infiltration of the tracheal mucosa associated with abundant thick secretions that formed adherent membranes within the tracheal lumen. In one of the articles two of the eight patients were reported to have suffered cardiorespiratory arrest.[2] In 1981 Liston, Gehry and Jarvis[3] described five children with bacterial tracheitis, two of whom died. In a retrospective chart review published in 1983 Sofer, Duncan and Chernick[4] described seven patients with this disease; the mean hospital stay was 20.8 days.

Since these publications several case reports and small series have established bacterial tracheitis as a distinct clinical entity that is difficult to diagnose and is associated with high morbidity and mortality rates. Questions remain about its causal relation to viral croup[5,6] and its management in intensive care units (ICUs).[7-9] Should endotracheal intubation or tracheostomy be the mainstay of ICU management? In the case of intubation, criteria for extubation have not been well established; there have been cases of airway obstruction and death after extubation.[7]

We report a series of patients with bacterial tracheitis who were managed in a pediatric ICU by means of nasotracheal intubation and sequential fibreoptic bronchoscopy so that sound diagnostic criteria and a safe and effective airway management regimen could be established.

Methods and patients

Between May 1982 and December 1987 all infants and children with signs of upper airway obstruction referred to the Pediatric Intensive Care Service at University Hospital, Saskatoon, were evaluated to identify those with possible bacterial tracheitis. The diagnostic criteria included clinical evidence of upper airway obstruction (e.g., stridor, croupy cough and difficulty in swallowing), abundant thick, purulent tracheal secretions and the growth of pathogenic bacteria from the tracheal secretions. The diagnosis was confirmed either by means of bronchoscopy or at autopsy. Information on the onset of symptoms and the course of the illness before admission was obtained from detailed patient histories.

All of the children who were alive on admission were managed with the use of nasotracheal intubation and continuous positive airway pressure. Inspired gases were humidified at a temperature of 32° to 34°C with the use of a Bennett Cascade Humidifier (Puritan-Bennett Canada Ltd., Vancouver) that was connected to a Siemens Servo 900C Ventilator (Siemens-Elema AB, Solna, Sweden). The nasotracheal tube was instilled with saline and suctioned every 2 hours or more frequently if secretions had to be evacuated. Pulse oximetry was used to monitor oxygen requirements; continuous electrocardiography was also used. Intravenous access was maintained, and broad-spectrum antibiotics (cefuroxime or chloramphenicol and cloxacillin) were eventually replaced with specific ones after the organism was identified through culture of the tracheal secretions. The patients were sedated with diazepam and morphine as required. Plaster casts were applied to the arms of certain patients to prevent accidental extubation. Rectal temperatures were recorded on admission and every 4 hours thereafter.

Chest radiographs were taken on admission and as clinically warranted to detect membranes within the trachea, narrowing and ulceration[1] of the trachea and pneumonic infiltrates. When possible, bronchoscopy was done daily through the nasotracheal tube to evacuate secretions, to evaluate the progress of the disease and to help determine when to extubate. If bronchoscopy was not possible extubation was done if there was an air leak around the nasotracheal tube, a decrease in temperature and a decrease in the amount and viscosity of the tracheal secretions.

On admission viral and bacterial cultures of the tracheal secretions were done, as were blood cultures, leukocyte and differential counts, and Gram's staining of the tracheal secretions.

Results

Clinical and diagnostic features

Fourteen patients (nine boys and five girls) were found to have bacterial tracheitis (one in 1982, two in 1985, two in 1986 and nine in 1987); 12 cases occurred between October and March and the other 2 in May and June. The patients' ages were from 7 months to 10¼ (median 3¼) years.

All of the patients presented with signs and symptoms of upper airway obstruction, the severity varying. Two of the children complained of a feeling of something in their throat. In two other cases the parents reported that the child had been coughing up rice-like particles. Wheezing in four children was treated with bronchodilators but without improvement. The use of a croup tent with cool mist and racemic epinephrine failed to relieve symptoms of viral croup in seven patients. The time between the onset of symptoms and diagnosis varied from 2 hours to 10 (mean 4.1) days. One child had concurrent supraglottitis.

The diagnosis was confirmed at autopsy in three patients, one a 25-month-old girl with toxic shock syndrome who died on a general pediatric ward 36 hours after admission and 4 days after the onset of symptoms. Bronchoscopy was used for diagnosis in nine patients; it was done daily through the nasotracheal tube in five, who had a

tube with an internal diameter of 5.0 or 5.5 mm. In the remaining two patients, aged 13 months and 15 months, intubation was done immediately because of impending total airway obstruction; bronchoscopy was not done on admission and could not be done later because the nasotracheal tube was too small. In both of these patients large amounts of purulent secretions seen pouring out from between the vocal cords at laryngoscopy were suctioned from the tube.

The body temperature on admission varied from 37.7° to 40.2° (mean 39°) C. The patients became afebrile (temperature less than 38°C) after 8 to 79 (mean 40) hours.

Bronchoscopic features

The abnormal findings at bronchoscopy, which were present throughout the trachea, were similar but varied in severity. In seven patients inflammation extended into the main bronchi and in one into the segmental bronchi. The mucosa was edematous, particularly in the subglottic area and at the carina and orifices of the main bronchi. The tracheal mucosa was markedly erythematous and very friable, and there were ulcerations, adherent membranous plaques of various sizes, and areas that resembled granulation tissue. The tracheal secretions were thick, stringy and sticky and adhered to the tracheal wall and nasotracheal tube.

In the five patients who underwent bronchoscopy daily the condition worsened over the first 5 to 9 days, before healing began. The amount of secretions, erythema, friability and edema of the mucosa decreased after 5 to 9 days. After about 6 days a circumferential pattern to the condition became evident that seemed to herald the beginning of healing. The tracheal edema, which seemed most severe at 5 to 9 days, also began to disappear at this time. Daily bronchoscopy was also useful in evacuating secretions adherent to the inside lumen of the nasotracheal tube that could not be removed by conventional suctioning. Large amounts of adherent secretions and membranes were sometimes seen at bronchoscopy; this was unexpected because of conventional suctioning or the clinical status.

Microbiologic features

The leukocyte counts on admission varied from 4.8 to 29.1 (mean 14.5) $\times 10^9$/L; 23% to 93% (mean 55%) of the cells were neutrophils, and 0% to 58% (mean 28%) were band cells. Only one patient did not have an increase in the proportion of immature cells. All patients had high leukocyte counts on Gram's staining of the tracheal secretions. Culture of the secretions yielded *Staphylococcus aureus* in seven patients (a strain producing enterotoxin A and F from the child that had toxic shock syndrome), *Haemophilus influenzae* in three, *Streptococcus pneumoniae* in one and *Branhamella catarrhalis* in one. One other patient had a mixed culture of *H. influenzae* and *B. catarrhalis*. Two of the four *H. influenzae* isolates and both of the *B. catarrhalis* isolates produced β-lactamase and were resistant to penicillin and ampicillin. One patient received antibiotics before admission, and no bacterium or virus was isolated from the tracheal secretions, even though the clinical features and bronchoscopic findings indicated bacterial tracheitis.

Viral cultures of the tracheal secretions yielded respiratory syncytial virus in one patient and parainfluenza virus type 2 in another. Blood cultures were positive for *H. influenzae* in only one patient, in whom the organism was also isolated from the tracheal secretions.

Radiographic features

A pneumonic infiltrate was noted in six patients on admission. Opaque pencil-line streaks, which represented membranes within the trachea, were seen in two. Narrowing of the trachea was seen in four. In one patient who had *B. catarrhalis* tracheitis the air cells in the maxillary and ethmoid sinuses were found to be poorly aerated.

Outcome

Three of the patients died. One died of unrecognized tracheitis and toxic shock syndrome on a general pediatric ward. Another had respiratory failure because of a plugged endotracheal tube during transportation to the hospital; she was resuscitated on arrival but was brain dead, and life support was stopped after 48 hours in the pediatric ICU. The third was a 13-month-old girl with staphylococcal tracheitis whose condition had been improving when an air leak developed around the nasotracheal tube 6 days after admission and severe irreversible bronchospasm, pneumothoraces and pneumomediastinum suddenly developed; mild inflammation and ulceration of the trachea were observed at autopsy, but no other cause could be found for the lower airway obstruction. This was the only death that occurred after admission to the pediatric ICU. The deaths occurred in 1982, 1985 and 1986. None of the nine patients seen in 1987 died.

One child had subglottic stenosis that necessitated tracheostomy. Two had severe croup after extubation; one had a prolonged hospital stay, 22 days, and the other was treated with a gas mixture of 70% helium and 30% oxygen and was discharged from hospital 2 days after extubation.

S. aureus was isolated from the three children who died and from the one with subglottic stenosis. Staphylococcal disease was more common and had a worse prognosis than nonstaphylococcal disease (Table I). There was no statistically signifi-

cant difference between the staphylococcal disease and the other forms with respect to the duration of symptoms before diagnosis, the temperature and the leukocyte count on admission, and the number of days of intubation or of hospital stay.

Discussion

We observed a fourfold increase in the incidence rate of bacterial tracheitis in 1987 as compared with 1985 and 1986. We are certain that this increase was not due to heightened awareness and recognition, because our prospective management protocol had been in place for several years. Bacterial tracheitis is currently the commonest cause of acute upper airway obstruction treated in our pediatric ICU. Whether the experience in 1987 represents a trend or an isolated clustering is unknown. We found, as did others,[2] that this disease occurs predominantly during the cold months.

Tracheitis is associated with high morbidity and mortality rates. Death can occur from such causes as upper airway obstruction, obstruction of the ventilation tube and severe bronchospasm. The occurrence of toxic shock syndrome has previously been described.[10,11] Death has occurred in children with an established tracheostomy.[3]

There is no unique or definitive laboratory feature or symptom; however, the presence of purulent secretions, pseudomembranes and ulcerations within the trachea does help to diagnose bacterial tracheitis. Physicians must suspect tracheitis in any child with croup, epiglottitis or pharyngeal infection that is atypical and does not respond to regular therapy. Harsh cough, hoarseness, coarse stridor and difficulty in swallowing were the prominent clinical features in the patients presented here.

The presence of large amounts of thick, stringy, sticky secretions and pseudomembranes at laryngoscopy or bronchoscopy indicates tracheitis. The secretions contain abundant leukocytes and pathogenic bacteria, such as *S. aureus*, *H. influenzae* and *S. pneumoniae*. There have been two reports of *B. catarrhalis* tracheitis.[12,13] *Branhamella* is usually thought of as a respiratory commensal but is increasingly being identified as a pathogen in children.[14,15]

Laryngoscopy and bronchoscopy should be done promptly and a patent airway be established to prevent death. Repeated bronchoscopy through the ventilation tube helps in removing secretions from the tube, the trachea and the bronchi that could not be removed with the use of conventional suctioning; this is accomplished through point suctioning and repeated saline lavage. Repeated bronchoscopy also helps in following the progress of the disease and in determining when to extubate.

At radiologic examination the detection of tracheal ulcerations or membranes helps to diagnose tracheitis,[1] but narrowing and fuzziness seen in the subglottic region or the presence of a pneumonic infiltrate are nonspecific findings.

Controversy exists as to whether bacterial tracheitis is a primary infection or a superinfection associated with an underlying viral illness. The concurrence of viral and bacterial pathogens has been described;[6] however, we found only two patients in whom this was the case.

The other controversy is whether tracheostomy or nasotracheal intubation should be used to establish a patent airway. The use of a nasotracheal tube was successful in this series of patients; no deaths from obstruction of the tube occurred in the pediatric ICU. Adequate humidification, vigorous suctioning and repeated endoscopy were successful in keeping the nasotracheal tube patent.

We recommend the management protocol that follows.

- If bacterial tracheitis is suspected an intravenous line should be established and direct laryngoscopy and rigid bronchoscopy be done under halothane anesthesia. If the diagnosis is confirmed, tracheal secretions and membranes, as well as bronchial washings, should be obtained for Gram's staining and culture; blood cultures should also be done. A nasotracheal tube should be inserted and the patient monitored in a pediatric ICU.
- Continuous positive airway pressure should be maintained and the oxygen therapy adjusted according to pulse oximetry findings.
- A high level of humidity should be maintained and the nasotracheal tube be suctioned as required.
- A broad-spectrum antibiotic (e.g., cefuroxime) should be given intravenously and then

Table I — Comparison of staphylococcal and nonstaphylococcal tracheitis in 14 patients

Type of tracheitis	Mean duration of intubation, d	Mean hospital stay, d	Outcome; no. of patients	
			Subglottic stenosis	Death
Staphylococcal infection	9.2	15.5	1	3
Nonstaphylococcal infection	6.7	10.0	0	0
Total	7.6	12.0	1	3

replaced with a more specific antibiotic after identification of the pathogen. Antibiotic therapy should be maintained for 10 to 14 days on the basis of clinical evolution.

- Sedation should be used as required. Plaster casts should be placed on the arms of certain patients to prevent accidental extubation.
- Bronchoscopy should be done daily or every other day to remove secretions and to monitor the course of the disease.
- The nasotracheal tube should be removed after the patient's temperature has returned to normal, if there is an air leak around the tube, if the quantity and viscosity of the secretions decrease and if signs of healing are observed at bronchoscopy.

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Meetings

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May 15-17, 1989: International Conference on the Spiritual, Pastoral and Ethical Issues in the Care of the Dying and Bereaved
King's College, London, Ont.
Followed by a 3-week study tour of China, exploring traditional and Western practices in health care, including the care of the dying and the bereaved, from June 24 to July 17, 1989.
Dr. John D. Morgan, Department of Philosophy, King's College, 266 Epworth Ave., London, Ont. N6A 2M3; (519) 433-3491

May 30-June 2, 1989: Catholic Health Association of Canada Annual Conference
Hilton Hotel, Saint John, NB
Freda Fraser or Ronald Carrière, Catholic Health Association of Canada, 1247 Kilborn Ave., Ottawa, Ont. K1H 6K9; (613) 731-7148

June 1-4, 1989: Ontario Pharmacists' Association Annual Meeting and Conference
Inn on the Park, Toronto
David Windross, 707-99 Avenue Rd., Toronto, Ont. M5R 2G5; (416) 922-7740, FAX (416) 922-5411

June 22-25, 1989: Canadian Medical and Biological Engineering Society Conference
Westbury Hotel, Toronto
Abstract deadline is Feb. 15, 1989.
Canadian Medical and Biological Engineering Society Secretariat, c/o National Research Council, Rm. 164, Building M-50, Ottawa, Ont. K1A 0R8; (613) 993-1686, FAX (613) 952-7998

July 2-5, 1989: Canadian Rockies Symposium — Cataract and Refractive Surgery
The Lodge at Kananaskis, Kananaskis Village, Alta.
Monica Comm, Gimbel Eye Foundation, PO Box 36, Stn. G, Calgary, Alta. T2A 2G1; (403) 286-3022, FAX (403) 286-2943

Oct. 1-5, 1989: Joint Annual Meeting of the Association of Canadian Medical Colleges, the Association of Canadian Teaching Hospitals and the Canadian Association for Medical Education
Westin Hotel, Winnipeg
Janet Watt-Lafleur, Association of Canadian Medical Colleges, 1006-151 Slater St., Ottawa, Ont. K1P 5N1; (613) 237-0070

Oct. 2, 1989: 4th Annual Conference on Physician Manpower
Westin Hotel, Winnipeg
Janet Watt-Lafleur, Association of Canadian Medical Colleges, 1006-151 Slater St., Ottawa, Ont. K1P 5N1; (613) 237-0070

Oct. 11-17, 1989: 52nd Annual Meeting of the Canadian Association of Radiologists
Hilton International Quebec and Municipal Convention Centre, Quebec
Canadian Association of Radiologists, 506-1440 St. Catherine St. W, Montreal, PQ H3G 1R8; (514) 866-2035