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Changing Epidemiology of Life-Threatening Upper Airway Infections: The Reemergence of Bacterial Tracheitis

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ABSTRACT

OBJECTIVE. As a consequence of evolving medical practice, the epidemiology of potentially life-threatening upper airway infections is changing. We report our experience over 9 years with viral croup, epiglottitis, and bacterial tracheitis.

PATIENTS AND METHODS. We studied a retrospective case series of patients admitted to Vermont Children’s Hospital with potentially life-threatening upper airway infections: viral croup, epiglottitis, or bacterial tracheitis between 1997 and 2006.

MEASUREMENT AND MAIN RESULTS. There were 107 patients with viral croup admitted to Vermont Children’s Hospital, with 16 (15%) admitted to the pediatric intensive care unit. Three patients with croup (17% of pediatric intensive care unit admissions, 3% of total admissions) required intubation. There were no serious complications. Eighteen patients were admitted with bacterial tracheitis. Ninety-four percent (n = 17) were admitted to the pediatric intensive care unit. Eighty-three percent (n = 15) were intubated. Twenty-eight percent of patients (n = 5) developed serious complications. Two adolescent patients were admitted with epiglottitis. Both were intubated and recovered without complications. Of 35 patients admitted to the pediatric intensive care unit with these potentially life-threatening upper airway infections, 20 patients (57%) developed respiratory failure. Fifteen patients (75%) had bacterial tracheitis, 3 patients (15%) had viral croup, and 2 patients (10%) had nonclassic epiglottitis.

CONCLUSIONS. Immunization against Haemophilus influenzae type b and widespread use of corticosteroids for the treatment of viral croup have changed the epidemiology of acute infectious upper airway disease. As potentially life-threatening infections, viral croup and epiglottitis have been eclipsed by bacterial tracheitis. In this series, bacterial tracheitis was 3 times more likely to have caused respiratory failure than viral croup and epiglottitis combined. Bacterial tracheitis should be considered in children who present with acute life-threatening upper airway infection.
A S A CONSEQUENCE of evolving medical practice, the epidemiology of potentially life-threatening upper airway infections is changing. Until recently, viral croup and epiglottitis have been considered the main etiologies of these infections. However, immunization against Haemophilus influenzae and treatment of viral croup with corticosteroids have changed the incidence, morbidity, and mortality of these diseases. We reviewed our experience over 9 years with serious upper airway infections in patients admitted to the Vermont Children’s Hospital with respect to changing epidemiology of these life-threatening upper airway infections.

METHODS
After approval was obtained from the University of Vermont Institutional Review Board, a retrospective chart review was made of patients admitted to Vermont Children’s Hospital with International Classification of Diseases, Ninth Revision codes of laryngotracheitis (464.20), tracheitis without obstruction (464.10), tracheitis with obstruction (464.11), laryngotracheobronchitis (490), acute laryngotracheobronchitis (466), acute bronchitis (466.0), laryngitis (464.0), croup (464.4), epiglottitis (464.3), epiglottitis with obstruction (464.31), and bronchitis not otherwise specified (490). An extensive chart review collected demographic data, admission and discharge diagnoses, presenting symptoms, and characteristics of the hospital courses.

RESULTS
Viral Croup
There were 107 patients with viral croup admitted to Vermont Children’s Hospital between 1997 and 2006. Diagnosis was made by clinical criteria (see Table 1). Routine viral identification was not performed. All of the patients were treated with nebulized epinephrine and parenteral corticosteroids. There were no serious complications.

Bacterial Tracheitis
Eighteen patients were admitted with the diagnosis of bacterial tracheitis. Diagnosis was made by bronchoscopy in 15 patients (83%) and on clinical grounds in 3 patients (17%; see Table 1). Clinical characteristics of these patients are found in Table 2. Seventy-eight percent of patients had a white blood cell (WBC) count <5000 (n = 5 [28%]) or >10 000 (n = 14 [50%]). Thirty-seven bronchoscopies were performed on 15 patients. These were performed on admission and to evaluate the trachea before extubation. Bronchoscopic findings on initial examination were uniform. All of the patients had erythema, edema, and thick purulent secretions with or without plaques or pseudomembrane formation. Repeat bronchoscopies before extubation were also uniform. All of the patients had clearing of secretions and edema, with minimal residual erythema.

Bacterial and viral cultures were obtained at bronchoscopy in 15 patients. Ten (67%) of 15 cultures were positive for the following organisms, with Staphylococcus aureus recovered in 60% of positive cultures: S aureus and Staphylococcus pneumoniae (2); S aureus and Moraxella catarrhalis (1); S aureus and influenza A virus (1); S aureus and influenza B virus (1); S aureus and respiratory syncytial virus (1); Streptococcus pneumoniae (1); group A β-hemolytic streptococcus and influenza B virus (1); H influenza and influenza A virus (1); and influenza B virus and mixed bacterial growth (1).

None of the Staphylococcal isolates were methicillin-resistant S aureus (MRSA). Virus identification was by antigen detection.

Twenty-eight percent of patients (n = 5) developed serious complications (n = 6). Four patients developed the acute respiratory distress syndrome (ARDS) with 2 requiring high-frequency oscillatory ventilation. All 4 of the patients with ARDS developed multiple organ dysfunction syndrome. One patient developed postobstructive pulmonary edema. One patient developed subglottic stenosis and required a tracheostomy.

All of the patients admitted to Vermont Children’s Hospital survived. One patient died before transport at a referring hospital. Autopsy findings were consistent with bacterial tracheitis, and cultures were positive for H influenza and S pneumoniae.

| TABLE 1 | Life-Threatening Airway Infections: 1997–2006 |
|-----------------|----------------------|----------------------|----------------------|
| Variable        | Bacterial Tracheitis | Viral Croup          | Epiglottitis         |
| PICU admissions, n (%) | 17 (48)              | 16 (46)              | 2 (6)                |
| Male/female     | 10.8                  | 7.9                  | 2.0                  |
| Age range       | 8 mo to 14 y          | 7 mo to 8 y          | 15 y                 |
| Age, mean ± SD (median), y | 5.6 ± 4.3 (3.75) | 2.6 ± 4.1 (1.8) | 15                   |
| Hospital LOS, range, d | 2–45                  | 2–10                | 4                    |
| Hospital LOS, mean ± SD (median), d | 11 ± 11 (7)       | 3.6 ± 2 (4)         | 4                    |
| PICU LOS, range, d | 1–36                  | 1–9                 | 3                    |
| PICU LOS, mean ± SD (median), d | 9.1 ± 8.8 (6.5)  | 3.6 ± 2 (4)         | 3                    |
| Respiratory failure | 15 (83%)             | 3 (19%)             | 2 (100%)             |
| Ventilator days, range | 3–21                  | 1–6                 | 2                    |
| Ventilator days, mean ± SD (median) | 7.5 ± 5.6 (6) | 3.3 ± 2.5 (3) | 2                    |
TABLE 2 Clinical Characteristics of Bacterial Tracheitis (n = 18)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cough, n/N (%)</td>
<td>17/18 (94)</td>
</tr>
<tr>
<td>Retractions, n/N (%)</td>
<td>17/18 (94)</td>
</tr>
<tr>
<td>Stridor, n/N (%)</td>
<td>16/18 (89)</td>
</tr>
<tr>
<td>Hoarseness, n/N (%)</td>
<td>12/18 (67)</td>
</tr>
<tr>
<td>Toxic appearance, n/N (%)</td>
<td>10/18 (56)</td>
</tr>
<tr>
<td>Drooling, n/N (%)</td>
<td>2/18 (11)</td>
</tr>
<tr>
<td>Temperature, range, °C</td>
<td>37–41</td>
</tr>
<tr>
<td>Temperature, mean ± SD (median), °C</td>
<td>38.8 ± 1 (38.8)</td>
</tr>
<tr>
<td>WBC, range, K</td>
<td>2.9–20.6</td>
</tr>
<tr>
<td>WBC, mean ± SD (median), K</td>
<td>9.9 ± 4.9 (8.6)</td>
</tr>
</tbody>
</table>

Epiglottitis

Two patients, both boys aged 15 years, were admitted in 1997 with epiglottitis (see Table 1). Diagnosis was made by direct laryngoscopy. Surface cultures of the epiglottis grew group A β-hemolytic streptococcus in 1 patient and non-typeable H influenza in the other. There were no serious complications in either case. Because of their ages, neither patient had been immunized against H influenzae type b.

Respiratory Failure

Thirty-five patients with potentially life-threatening upper airway infections were admitted to the PICU with the diagnoses of epiglottitis (n = 2 [6%]), viral croup (n = 16 [46%]), and bacterial tracheitis (n = 17 [48%]). Twenty (57%) of these patients developed respiratory failure. Fifteen patients (75%) had bacterial tracheitis, 3 patients (15%) had viral croup, and 2 patients (10%) had nonclassic epiglottitis.

DISCUSSION

In first description of bacterial tracheitis in the American literature, Jackson1 credited Pierre Blaud, a French physician, for reporting the disease in 1823. Serious nontypable bacterial infections of the trachea in children were described following the 1918 influenza pandemic. This literature continued until the mid-1940s. In 1948, Rabe12-14 described 3 separate acute infectious processes of the upper airway: diphtheritic croup, H influenza croup (epiglottitis), and “virus” croup. Bacterial tracheal infections were omitted. This subject disappeared from pediatric textbooks and literature15 until 1979, when Jones et al16 reported 8 cases of an acute airway obstructive disease with features common to both croup and epiglottitis. They named this illness bacterial tracheitis.

Bacterial tracheitis is an uncommon upper airway infection that can cause life-threatening airway obstruction. Patients may present with symptoms resembling viral laryngotracheobronchitis or epiglottitis. The diagnosis is usually made by direct visualization with bronchoscopy. Patients typically have a brief prodrome of symptoms consistent with viral upper respiratory tract infection, such as rhinorrhea, low-grade fever, cough, sore throat, and hoarse voice. Patients typically become rapidly more symptomatic with respiratory distress, increased work of breathing, airway compromise, higher fever, and toxic appearance. The mortality rates had been reported as high as 18% to 40%.18

Significant morbidity associated with bacterial tracheitis may include: respiratory and cardiopulmonary arrest, respiratory failure, pneumonia, septic shock, toxic shock syndrome, ARDS, and multiple organ dysfunction syndrome.19-28 Respiratory failure requiring intubation and mechanical ventilation is commonly reported.21

Our experience is consistent with this literature, with a PICU admission rate of 94%, an intubation rate of 83%, and serious complication rate of 28%. Our bacteriology also reflects the reported literature.19–21,29,30 Although 6 of 15 cultures were positive for S aureus, 5 of 15 were positive for influenza virus. We cannot exclude the possibility that these patients may have had a primary viral tracheitis with secondary bacterial colonization, as opposed to bacterial infection or infection. We did not identify a subset of bacterial tracheitis in older patients with milder manifestations that has been reported recently.31,32 This study is limited by the retrospective design and by the potential ambiguity of the clinical diagnosis of bacterial tracheitis in 3 patients who did not undergo bronchoscopy.

Just as laryngeal diphtheria disappeared after immunization programs after World War II,33 H influenza type b epiglottitis seems to have done the same.2 A 4-year study of children in Norway reports that bacterial tracheitis has exceeded the incidence of epiglottitis in that country.34 There were no cases of classic early childhood H influenza type b epiglottitis in the 9-year study period.

Before the routine use of corticosteroids, ≤10% of children admitted with viral croup required intubation.7 The widespread use of corticosteroids for viral croup has had a major impact on morbidity of this disease.3-7 There are now data that support recommendations for the use of corticosteroids in even mild croup.5,35

In this series, 35 patients with potentially life-threatening upper airway infections were admitted to the PICU with the diagnoses of epiglottitis, viral croup, or bacterial tracheitis. Twenty of these patients developed respiratory failure. Bacterial tracheitis was 3 times more likely to have caused respiratory failure than viral croup and epiglottitis combined.

CONCLUSIONS

Bacterial tracheitis, a rare illness, has emerged as the most common potentially life-threatening upper airway infections in children. This illness could emerge in association with a contemporary influenza pandemic to replicate the tracheal complications reported after the 1918 pandemic. The increasing burden of serious MRSA infections may also contribute to the changing epidemiology and virulence of this disease.36,37 Bacterial tracheitis...
should be considered in all children who present with acute life-threatening upper respiratory infection.

**ACKNOWLEDGMENTS**

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**REFERENCES**

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