ABSTRACT
Providers in pediatric emergency departments (ED) frequently encounter a variety of life-threatening respiratory illnesses. This article reviews current updates on the management and unique adjuncts for 3 common respiratory illnesses. Discussed first is bronchiolitis and the impact of high flow nasal cannula on reducing the need for intubation. Next, the current therapy for croup and the adjunctive use of Heliox and finally, the ED approach to asthma and treatment with breath actuated nebulizers.

KEYWORDS: pediatrics, respiratory care, bronchiolitis, asthma, croup

BRONCHIOLITIS
Bronchiolitis is a lower respiratory tract illness that produces acute inflammation, edema, and necrosis of epithelial cells lining small airways, leading to increased mucous production and bronchospasm. In winter, bronchiolitis is the number one reason infants are admitted to hospitals and a significant portion of infants is cared for in Hasbro Children’s Hospital Emergency Department (HCH ED).

The HCH ED follows the American Academy of Pediatrics (AAP) bronchiolitis management recommendations, which emphasize the importance of clinical assessment and supportive care. Noninvasive interventions are the first line approach to bronchiolitis. Infants are suctioned (by bulb or suction catheter) and repositioned to improve airway patency. The impact of bronchiolitis on infant feeding and hydration can be significant. Infants unable to tolerate milk products or with mild dehydration may attempt oral hydration with Pedialyte. Patients admitted may receive nasogastric tube feeding if there is moderate dehydration or mild respiratory distress during feeds. This provides enteral nutrition and hydration while minimizing trauma. Intravenous hydration is reserved for infants with moderate to severe respiratory distress or dehydration.

As per AAP guidelines, bronchodilators may be given as a trial with observation for positive clinical response but are not routinely repeated unless there is clinical benefit. Similarly, corticosteroids are not routinely used in the management of bronchiolitis given the insufficient evidence to improve length of stay or clinical score. A novel therapy for bronchiolitis is nebulized 3% hypertonic saline. The saline concentrate causes osmotic movement of water from the pulmonary interstitium into the airways, thereby decreasing interstitial edema and viscosity of intraluminal mucous. The preliminary evidence shows mixed results with some reports of decreased length of stay and others showing no clinical effect. There are no studies that demonstrate impact of emergency department visits. All studies on hypertonic saline report no harm or adverse effects.

Despite interventions, some infants with bronchiolitis have persistent respiratory distress that requires additional support such as high flow nasal cannula (HFNC). HFNC provides heated, humidified airflow via a wide-diameter cannula. The shorter, wider nasal prongs provide increased flow at lower resistance than traditional nasal cannulas, and humidification prevents desiccation of the nasal mucosa that can occur with high flow rates. It serves as an alternative form of respiratory support than nasal continuous positive airway pressure in infants.

HFNC has revolutionized the management of infants with moderate to severe bronchiolitis, often removing the need for intubation. HFNC has been studied in infants with bronchiolitis in the emergency department (ED), pediatric intensive care unit (PICU), and pediatric ward settings. The primary indication to initiate HFNC is moderate to severe respiratory distress in infants, based on tachypnea, hypoxia, and accessory muscle use. HFNC significantly increases median SpO2 by 1-2%, decreases end tidal CO2 by 6-8 mmHg, and decreases respiratory rate by 13-20 breaths per minute, as compared to standard nasal cannula. This adjunct therapy improves heart rate and respiratory rate within 60-90 minutes, and therefore HFNC in bronchiolitis may decrease the need for intubation. After institutional guidelines for HFNC use were implemented for infants in one ED there was 83% reduction in the number of intubations.

There are preliminary data that children with bronchiolitis benefit from use of Heliox. Heliox is a gaseous mixture of helium and oxygen and is frequently combined in 80%/20% or 70%/30% ratios. Helium’s property of lower density leads to laminar flow of inspired gas across a narrowed airway, and therefore improves oxygen delivery particularly in upper airway obstructive processes. Carbon dioxide diffuses through helium 4-5 times faster than through air, thus Heliox improves gas exchange at the alveolar level. In infants with bronchiolitis, Heliox decreases work of breathing and
improves respiratory scores particularly in the first hour of use.\textsuperscript{10-12} Despite these improvements, Heliox use has not been shown to affect the rate of intubation or PICU length of stay.\textsuperscript{11}

At the HCH ED, respiratory therapists supply HFNC with an oxygen blender using an institutional protocol of flow based on age (Figure 1). At this institution, HFNC is initiated for children ages < 6 months at 2-8 L/min, ages 6-18 months at 4-12 L/min, and ages > 18 months at 8-15 L/min. Rate of flow and fraction of inspired oxygen (FiO\textsubscript{2}) is titrated to effect of improved work of breathing and maintaining SpO\textsubscript{2} > 92\%. The majority of patients requiring HFNC are admitted to the PICU, except in high-patient volume months during the winter. Anecdotal data from the HCH PICU show a 50\% decline in rates of intubation on patients started on HFNC since it became routinely used in 2009, as compared to 2012 (55 versus 27 patients, respectively).

**CROUP**

Croup, also known as laryngotracheobronchitis, is characterized by inflammation and edema of the subglottic area causing hoarseness, barking cough, and in some cases inspiratory stridor. Croup is often preceded by symptoms of an upper respiratory tract infection, frequently caused by viral pathogens, parainfluenza or influenza.\textsuperscript{13,14} Patients with croup frequent EDs due to the acuity of onset of stridor and respiratory distress, particularly during the night.

The first line of treatment for croup is glucocorticoids. Glucocorticoids have demonstrated improvement in croup scores at 6 and 12 hours, decreased return visits or readmissions, and decreased ED and hospital length of stay.\textsuperscript{14} Glucocorticoids reduce the subglottic swelling and inflammation, thereby improving respiratory effort. Children with inspiratory stridor and respiratory distress due to croup are treated with nebulized racemic epinephrine which causes upper airway vasoconstriction and therefore decreasing edema. It improves croup scores by 30 minutes post-treatment, although no significant improvement is seen at 2 or 6 hours post treatment.\textsuperscript{15} The HCH ED utilizes dexamethasone routinely in patients with croup, and nebulized racemic epinephrine in those with distress, followed by a 2-4 hour observation period for recurrent stridor or respiratory distress.

Children with refractory croup may benefit from Heliox. Heliox improves respiratory scores in children with croup, and has similar efficacy to racemic epinephrine, without the adrenergic side effects.\textsuperscript{9,13,16,17} The major impediment to Heliox use is hypoxia because of the limited FiO\textsubscript{2} that can be achieved due to a high concentration of helium versus oxygen. In addition, the tanks and blenders are cumbersome, and require knowledge of the equipment, thus limiting use to respiratory therapists. Heliox is therefore best used as an adjunct in croup for children with medical conditions that may be exacerbated by racemic epinephrine use, or those with persistent stridor despite multiple doses of racemic epinephrine.

Heliox is supplied by the respiratory therapy department at Hasbro Children’s Hospital, and is typically used with HFNC prongs in infants or non-rebreather facemask in children (Figure 2). The helium:oxygen ratio is titrated to maintain normoxia and flow rate of nasal cannula is adjusted to improve respiratory distress.

Figure 1. The equipment setup for heated, humidified, high flow nasal cannula. Below: A comparison of the wider diameter of HFNC prongs to the standard infant/small child nasal cannula prongs.

Figure 2. Depicted is the setup and equipment for Heliox, applied with a non-rebreather mask.
Asthma

Asthma is a chronic condition of airway inflammation and hyperreactivity, and is a frequent reason for ED visits. Beyond treating acute asthma exacerbations, the HCH ED serves as an alternative setting to initiate education and improve primary care linkage for children with poorly controlled asthma.

HCH ED providers treat asthma as recommended by the National Heart, Lung, Blood Institute (NHLBI) guidelines. Nebulized albuterol and ipratropium (Duoneb) are used for initial management of moderate-to-severe asthma exacerbations, and are administered with breath-actuated nebulizers (BANs).

BANs have been introduced in the last 10-15 years for efficient nebulized medication delivery for patients with asthma. When used in the appropriate clinical scenarios BANs are cost effective. BAN devices deliver aerosol particles at the onset of inhalation, thus limiting the loss of aerosol during exhalation. Only 4% of medicine is lost to the environment versus > 30% with the conventional nebulizer. Randomized pediatric trials of conventional nebulizer versus BAN during asthma exacerbations demonstrated superior results of BAN on asthma scores, respiratory rates, spirometry, oxygen saturation, length of stay, and admission rates. BANs can be used with a mouthpiece for older children, or tight-fitting facemask for the younger child and are routinely utilized for children of all ages with asthma in the HCH ED (Figure 3). Due to more effective medication delivery children are reassessed after each nebulized treatment to determine need for further treatments.

For infants who are unable to generate enough force to deliver the aerosol, the nebulizer may be converted to continuous administration with a twist of the top of the device (Figure 3). Use of the BAN for continuous delivery, however, is not as cost effective as more traditional nebulizer delivery systems that provide continuous delivery. In older children with mild symptoms, multi-dose inhaler (MDI) with a spacer is administered. Observation of MDI use by ED staff provides an opportunity for education about administration techniques.

Management of acute asthma includes systemic corticosteroids to reduce airway inflammation in patients who do not completely respond to a single albuterol treatment. Oral prednisone or dexamethasone is utilized in patients who can tolerate oral medication, and IV methylprednisolone is reserved for severely ill or vomiting patients. Due to its 36-72 hour half-life, dexamethasone is often administered in 2 doses: day 1, and day 2 or 3. Children who do not respond to first-line therapies are typically given continuous albuterol and adjunctive treatments such as IV fluids, IV magnesium sulfate and those with significant distress may benefit from additional respiratory interventions such as Bipap or Heliox.

Heliox may improve medication delivery to obstructed airways in children with asthma by improving laminar flow, but the limited data available has not demonstrated consistent benefits. One study showed improvement in asthma scores in the ED, but other studies showed no difference in asthma scores or length of stay.

Prior to discharge from the ED, steps are taken to maximize outpatient asthma management. HCH ED providers regularly communicate with the primary care provider, educate families on an asthma action plan, and if indicated, initiate inhaled corticosteroids or refer to the “Draw A Breath” program which is an innovative asthma education program that provides families with the knowledge and skills to manage asthma and serves over 800 families in Rhode Island.

CONCLUSION

Respiratory illnesses are common pediatric conditions that often require emergency treatment. Unique modalities are available in a tertiary pediatric emergency department for the care of children with 3 common respiratory illnesses:
bronchiolitis, croup and asthma. In addition to traditional guideline-based therapies, the HCH ED has incorporated several treatment adjuncts including HFNC, Heliox, and BANs. HFNC or Heliox use are currently limited to the hospital environment, however, BANs are a simple and cost-effective device that can be integrated into the primary care, urgent care, or community ED setting.

References

Authors
Therese L. Canares, MD, is affiliated with Hasbro Children’s Hospital/The Warren Alpert Medical School of Brown University, Providence, RI.
Craig Tucker, RRT-NPS, is affiliated with Hasbro Children’s Hospital/The Warren Alpert Medical School of Brown University, Providence, RI.
Aris Garro, MD, MPH, is Assistant Professor, The Warren Alpert Medical School of Brown University, and Pediatric Emergency Medicine Attending, Hasbro Children’s Hospital, Providence, RI.

Disclosures
None

Correspondence
Therese L. Canares, MD
593 Eddy St., Claverick 2nd Floor
Providence RI 02903
401-444-6680
fax 401-444-2583
therese.canares@gmail.com