CHEST Critical Care

Managing Critical Bronchiolitis

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Critical bronchiolitis is a common PICU diagnosis. It is a clinical diagnosis made in children younger than 2 years with low-grade fever, respiratory distress, rhinorrhea, cough, and wheezing. Like many experts, we now consider bronchiolitis to be a syndrome in which some children have uncomplicated viral disease, some have reversible bronchospasm and inflammation, and some have secondary bacterial infection. For all children, we routinely obtain a chest radiograph and basic laboratory tests. For most children, we treat them for uncomplicated viral disease with supportive care highlighted by thoughtful respiratory support. For most children, this consists of high-flow nasal cannula oxygen with flows of 1 to 2 L/kg/min and supplemental oxygen to target oxygen saturations of 92% to 97%. We routinely start enteral nutrition while administering oxygen via high-flow nasal cannula. We provide close monitoring and generally are tolerant of episodes of worsening respiratory distress and instability. We trial racemic epinephrine and then escalate to positive-pressure ventilation if refractory hypoxemia, encephalopathy (indicative of hypercarbia), and sustained severe dyspnea with evidence of systemic stress (eg, moderate to severe tachycardia) develop. On occasion, we treat children with profuse evidence of an asthma phenotype with bronchodilators and corticosteroids, although recognize that no reliable way exists to identify such children at the bedside. For children requiring invasive ventilation, we obtain culture samples of the lower airways shortly after intubation, begin empiric antibiotics, and complete a course if bacterial pathogens are identified. Ventilation strategies must be personalized based on ventilator parameters and physical examination findings, because signs of both obstructive and restrictive disease may be present. CHEST 2025; 3(2):100135

KEY WORDS: bronchiolitis; pediatrics; respiratory syncytial virus

Case Report: Part 1

Baby J is a previously healthy 9-month-old male infant who sought treatment at an emergency room with 3 days of low-grade fever, cough, congestion, and fussiness and 1 day of increased work of breathing. A chest radiograph showed perihilar infiltrates, respiratory syncytial virus was detected, and a normal saline bolus was administered. He was admitted to the general floor with oxygen administered via high-flow nasal cannula (HFNC) at 1 L/kg/min of flow and an F_{IO_2} of 30%. A few hours later, he was transferred to the PICU because of escalating HFNC settings and frequent alarms for desaturation, tachypnea, and tachycardia.

On PICU admission, his temperature was 38.3 °C and heart rate while calm was 130 to 140 beats/min. Respiration was 70 breaths/

ABBREVIATIONS: HFNC = high-flow nasal cannula; IMV = invasive mechanical ventilation; IVF = IV fluid; NC = nasal cannula; Spo_2 = oxygen saturation

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DOI: https://doi.org/10.1016/j.chstcc.2025.100135

min with an oxygen saturation (Spo_2) of 95% with 2 L/kg/min of HFNC oxygen with Fio_2 of 40%. Breath sounds were coarse bilaterally with good air entry and diffuse expiratory wheezing. He appeared to be alert, well perfused, and well hydrated. He had moderate to severe increased work of breathing while calm with nasal flaring and suprasternal and subcostal retractions, with periods of marked increases in work of breathing, desaturations to 84% to 88%, and tachycardia to 170 to 180 beats/min associated with coughing that resolve over several minutes.

What Is Bronchiolitis?

Viral bronchiolitis is one the most common diagnoses among hospitalized children in the United States.[1] Cases of critical bronchiolitis treated in the PICU represent 5% to 10% of PICU admissions in the United States, making it the most common PICU diagnosis.[2] Although critical bronchiolitis has been defined based on a patient's physical location in the PICU, some hospitals may use ICU-level respiratory support such as HFNC oxygen administration and CPAP on general wards, and this review may be applicable to such patients.[3-5] Historically, seasonal peaks occurred in the United States each winter, although epidemiologic factors since the onset of the COVID-19 pandemic have been atypical and irregular. In 2009, bronchiolitis accounted for $1.73 billion in charges in the United States, and the financial burden has increased since that time, primarily driven by critical bronchiolitis.[1,3] The most common cause of bronchiolitis is respiratory syncytial virus, followed by rhinovirus and several other viruses.[6] Worldwide, tens of thousands of children die each year of bronchiolitis.[7] Mortality is quite low in high-income countries, but it has been shown that approximately 10% of critically ill patients with bronchiolitis in the United States have evidence of post-PICU morbidity.[3,8] Approximately 25% of children have long-term pulmonary morbidity, and patients' parents also may have short-term and longer-term stressors and morbidity.[9-11]

How Is Bronchiolitis Diagnosed?

Bronchiolitis is a clinical diagnosis, typically made in children younger than 2 years with low-grade fevers, tachypnea, and signs of both upper (rhinorrhea, congestion, and so on) and lower (wheezing, cough, and so on) respiratory tract disease.[12] After making this clinical diagnosis, we routinely obtain a chest radiograph and select laboratory tests if not already done. Chest radiographs can rule out other causes of respiratory distress (eg, congenital heart disease, foreign body) and may help to personalize therapy (bronchodilators for hyperinflation and so on). We routinely test for influenza when it is circulating in our community to guide antiviral treatment. We routinely measure serum electrolytes, blood urea nitrogen, and creatinine to assess hydration and renal function and to guide IV fluid (IVF) management. Hyponatremia is associated with worse outcomes, and isotonic IVF should be standard.[13,14] In rare cases requiring prolonged IVF, repeat measurement in 24 to 48 hours can evaluate for hyperchloremic metabolic acidosis, which can worsen tachypnea and may warrant a change in IVF composition. A CBC count and inflammatory markers can be helpful to identify concurrent bacterial infections, although they may not be needed in uncomplicated cases. Guidelines for the diagnosis and treatment of bronchiolitis from expert groups around the globe are available (Table 1, e-Table 1). These guidelines do not recommend routine laboratory tests and imaging for typical inpatients on the general ward, but have limited applicability to our patients, given the exclusion of critical patients with bronchiolitis from much of the supportive evidence.[12,15-18]

Is Bronchiolitis a Disease or a Syndrome?

How we manage bronchiolitis is complicated by the fact that bronchiolitis is diagnosed in children with varying pathophysiologic features. What long has been suspected at the bedside has borne out in studies showing various phenotypes of bronchiolitis associated with different treatment approaches, illness severities, and long-term sequalae.[19-21] Experts worldwide now consider bronchiolitis (in clinical practice) to be more of a clinical syndrome than a single diagnosis, with variations related to causative virus, host response, and presence of secondary complications. In our mental model, some children have uncomplicated viral disease, some have reversible bronchospasm and inflammation, and some have secondary bacterial infection. Relatedly, the same child could receive a diagnosis with any one of several overlapping terms, such as *bronchiolitis*, *pneumonia*, *reactive airway disease*, and so on, from different physicians. We aim to personalize treatment based on our best understanding of that child's pathophysiologic features within the umbrella diagnosis of bronchiolitis, although evidence-based ways to identify drug-responsive phenotypes at the bedside precisely currently are lacking, and thus are a research priority.

TABLE 1] Abridged Recommendations From Expert Guidelines That May Be Pertinent to Critical Bronchiolitis

Guideline	American Academy of Pediatrics (2014)	Canadian Pediatric Society (2021)	Australasian Bronchiolitis Guideline (2022)	National Institute of Health and Care Excellence (2021)	French Speaking Group for Pediatric Intensive and Emergency Care (2023)
Intended population	Generally healthy children < 2 y	Generally healthy children < 2 y	Infants < 12 mo who are not admitted to a PICU	Children < 2 y	Infants < 12 mo admitted to a PICU
Diagnostic tests					
Chest radiograph	"Should not be obtained routinely"	"not indicated for most children. . . . Only if severity or course suggests alternate diagnosis"	"Not routinely indicated"	"Do not routinely perform . . . [consider] if intensive care is being proposed"	"Should not be routinely performed . . . [unless] signs of . . . complications or [alternate] diagnoses"
Blood tests	"Should not be obtained routinely"	"Not indicated for most children" • BG if suspected impending respiratory failure • Na if receiving IV fluids	"Have no role in management"	"Do not routinely perform" • BG if suspected impending respiratory failure	"No systemic biological monitoring" • BG for clinical deterioration • Na if signs of hyponatremia
Testing for viruses	"Routine virologic testing is not recommended"	"Not indicated for most children . . . [except] for infection control purpose or in high risk patients . . . [to prescribe] Oseltamivir for influenza"	"Has no role in management . . . including [for] cohorting of bronchiolitis patients"	No recommendation	"Should probably not be performed. . . . No evidence . . . [that it] allows zoning of patients to avoid viral spread"
Testing for bacteria	"Routine screening for [SBI] among hospitalized febrile infants between 30 and 90 days of age is not justified"	"Bacterial cultures . . . may be indicated based on clinical judgement"	"[Urine] culture may be considered . . . [if fever] in an infant < 2 mo of age"	No recommendation beyond: "Do not routinely perform blood tests"	No recommendation
Treatments					
β-agonist bronchodilators	"Should not administer. . . . One small [PICU] study showed a small decrease in inspiratory resistance . . . accompanied by clinically significant tachycardia . . . [which] does not justify . . . routine [use]"	"Not recommended"	"Do not administer . . . including [to children] with a personal or family history of atopy"	"Do not use"	"Should probably not be used routinely. In some cases, a therapeutic test could be considered to avoid intubation"

(Continued)

TABLE 1] *(Continued)*

Guideline	American Academy of Pediatrics (2014)	Canadian Pediatric Society (2021)	Australasian Bronchiolitis Guideline (2022)	National Institute of Health and Care Excellence (2021)	French Speaking Group for Pediatric Intensive and Emergency Care (2023)
Inhaled hypertonic saline	"May administer [to inpatients] . . . if the average length of stay is > 72 hours. . . . It has not been studied in [PICU]"	"Not recommended"	"Do not administer"	"Do not use"	"Should probably not be used routinely"
Inhaled epinephrine	"Should not administer . . . except potentially as a rescue agent in severe disease"	"Evidence equivocal . . . insufficient evidence to support its routine use in admitted patients"	"Do not administer"	"Do not use"	"Should probably not be used routinely. . . . [Consider] a therapeutic test . . . to avoid intubation"
Corticosteroids	"Should not administer"	"Not recommended"	"Do not administer . . . including [to children] with a positive response to beta 2 agonists"	"Do not use"	"Should probably not be used"
Antibiotics	"Should not administer . . . unless there is concomitant bacterial infection, or a strong suspicion of one. . . . May be justified in some children . . . who require intubation"	"Not recommended . . . except in cases in which there is clear evidence or strong suspicion of a secondary bacterial infection"	"Do not use"	"Do not use"	"Should not be systematically used but should be reserved for suspected pulmonary superinfection or bacterial co-infection"
Oxygen saturation target	> 90%	≥ 90%	≥ 92%	≥ 90% if age ≥ 6 wk and generally healthy, ≥ 92% for others	≥ 92%
Suctioning	"Insufficient data to make a recommendation. . . . 'Deep suctioning' may not be beneficial"	"Evidence equivocal . . . [if] performed, it should be done superficially and reasonably frequently"	"Not routinely recommended. Superficial nasal suction may be considered in those with moderate disease to assist feeding. Deep nasal suction . . . is not recommended"	"Do not routinely perform. . . . [Consider if] respiratory distress or feeding difficulties because of upper airway secretions"	No recommendation

(Continued)

TABLE 1 (*Continued*)

Guideline	American Academy of Pediatrics (2014)	Canadian Pediatric Society (2021)	Australasian Bronchiolitis Guideline (2022)	National Institute of Health and Care Excellence (2021)	French Speaking Group for Pediatric Intensive and Emergency Care (2023)
Noninvasive respiratory support	"Absence of any completed randomized trial of the efficacy of HFNC in bronchiolitis precludes specific recommendations"	"Insufficient evidence to support . . . routine use [of HFNC]"	"HFNC can be considered in the presence of . . . Spo_2 < 92% [despite nasal cannula] and moderate to severe recessions. Nasal CPAP . . . may be considered"	"Consider CPAP . . . [for] impending respiratory failure (e.g. signs of exhaustion, recurrent apnea; or [hypoxia] despite oxygen supplementation")	"[Initiate HFNC at] 1.5-2 L/kg/min . . . [and do] not exceed 2 L/kg/min. . . . CPAP should probably be . . . [first-line for severe cases at] 7 cmH_2O . . . NIV with two pressure levels [is suggested if CPAP fails] . . . unless intubation criteria [are present]"
Chest physiotherapy	"Should not use"	"Not recommended"	"Not recommended for routine use"	"Do not perform. . . . Consider [if] comorbidities . . . [with] difficulty clearing secretions"	"Should probably not be systematically performed . . . A therapeutic trial may be acceptable"

BG = blood gas; HFNC = high-flow nasal cannula; Na = serum sodium level; NIV = noninvasive mechanical ventilation; Spo_2 = oxygen saturation.

What Is the First-Line Respiratory Support Method for Bronchiolitis?

The most important element of bronchiolitis care is adequate, but not excessive, respiratory support. Options beyond simple nasal cannula (NC) oxygen administration include HFNC oxygen administration, CPAP, bilevel positive airway pressure, and invasive mechanical ventilation (IMV).[6] HFNC is being used with increasing frequency.[22] HFNC heats and humidifies the inspired gas, which allows higher gas flow rates while maintaining patient comfort.[23] Its primary mechanism is washout of the CO_2-rich nasopharyngeal gas with oxygen-rich gas, which improves both oxygenation and ventilation. Other mechanisms include reducing metabolic work of the nasopharynx and providing variable, non-dose-dependent levels of pharyngeal pressure, although thoracic pressures from HFNC oxygenation are not substantially higher those generated by NC administration.[24,25] It is imperative to keep > 50% of the nares unobstructed to allow washout and to prevent inadvertent generation of excessive intrathoracic pressures that can risk pneumothorax. HFNC oxygenation reduces risk of treatment failure compared with NC oxygenation, and some observational data suggest that the former reduces rates of intubation, but definitive evidence proving it improves clinical outcomes is not available.[23,26,27] HFNC oxygenation is easy to set up, has minimal side effects, is well tolerated with little need for sedation, allows for freedom of movement, and enables oral nutrition. Thus, it is our first-line respiratory support method in nearly all children with critical bronchiolitis with respiratory failure. We generally use flows of 1-2 L/kg/min and provide an F_{IO_2} of at least 30%, titrated to maintain Spo_2 of 92% to 97%. Although some children with critical bronchiolitis have peak inspiratory flows of > 2 L/kg/min and thus could benefit from higher flows, a trial of 3 L/kg/min vs 2 L/kg/min showed no benefit, and an observational study showed that HFNC oxygenation works in a dose-dependent fashion with greatest effects occurring at 1.5 to 2 L/kg/min.[28-30]

The first-line support method used by many intensivists is CPAP, which can maintain airway patency, can provide oxygen, and can increase functional residual capacity.[15,23] The largest direct comparison of CPAP vs HFNC in bronchiolitis demonstrated an increased failure rate with HFNC, although a subsequent study by that group called that result into question.[31,32] Multiple other bronchiolitis trials show equivalency between CPAP and HFNC, as did the landmark First-Line Support for Assistance in Breathing in Children (FIRST-

ABC) trial, in which bronchiolitis was the most common condition.[33] HFNC is better tolerated, is easier to set up, and has overall similar effectiveness, which is why we use it as the first-line method in our PICU.

When Should Respiratory Support Methods Be Changed?

Regardless of whether HFNC or CPAP is used as the initial method of support, we evaluate patients for 3 general conditions that prompt a change in method: refractory hypoxemia (eg, $>$ 60% F_{IO_2} to maintain $Sp_{O_2} \geq 90\%$), encephalopathy (as a clinical marker of significant hypercarbia or hypoperfusion), and sustained severe dyspnea with evidence of systemic stress (eg, moderate to severe tachycardia especially when calm). Blood gas analysis also can be used to assess ventilation, but hypercarbia that is mild enough to not be detected clinically may not warrant aggressive maneuvers that risk adverse events in a generally self-limited disease like bronchiolitis. In trials comparing HFNC with CPAP, both methods were used successfully to rescue a child failing the other, so it is reasonable to try CPAP for a child failing HFNC, and vice versa.

Our patient, Baby J, was quite tachypneic and distressed at rest with 2 L/kg/min of oxygen, with periods of severe distress and vital sign instability. This may prompt some to escalate support. However, we would not because his oxygenation was adequate with a modest FiO_2, he was alert, and his heart rate was normal when calm, which indicates that he was not having a substantial stress response, despite the increased respiratory effort, and that the current level of support overall was sufficient. The downsides of positive pressure ventilation (especially IMV) far outweigh those of short-term close monitoring of moderate to severe respiratory distress for most patients. A key element to this approach is serial re-evaluation of the patient and discussions with family and junior bedside staff so they understand what we are monitoring for. This approach requires favorable staff to patient ratios like those available in the PICU. Although many centers use HFNC on the general wards, this has been associated with increases in use of the method without clear benefit (and possible prolongation of hospitalization) and risks acute decompensation in less-resourced environments.[4,34,35] When HFNC is used to treat true respiratory failure (as opposed to respiratory distress), we believe it should be done only in a PICU. Developing evidence-based criteria for when, where, and how best to initiate, monitor, and wean HFNC and CPAP—including identifying patient factors predictive of preferential response to 1 method over the other—would be a major advance in the field.

How Should HFNC Be Weaned?

It is important to promptly discontinue HFNC when respiratory failure improves so as not to waste resources, especially when it is restricted to the PICU. Recently published quality improvement studies show that weaning protocols, including rapid discontinuation so-called holidays, improve clinical outcomes.[36] For Baby J, we would use our local respiratory therapist-driven protocol of objective assessments every 4 hours using a proprietary score to decrease flow toward NC and discontinue HFNC promptly as disease status improves. Similar to published weaning protocols, we serially assess vital signs (heart rate, respiratory rate, and Sp_{O_2}) and physical examination findings (effort of breathing, perfusion, and mental status) with a score less than the assigned threshold for weaning, which is done in 0.5 L/min/kg increments at our institution.[37] Importantly, children still can have modestly abnormal vital signs, physical examination findings, or both and still be weaned successfully; waiting for complete resolution of all symptoms likely would prolong hospitalization unnecessarily.

When Should Bronchodilators and Corticosteroids Be Administered?

None of albuterol, racemic epinephrine, and corticosteroids are recommended for routine use by international guidelines. Airways obstruction and wheezing in bronchiolitis can be caused by any combination of mucus or debris, edema, and reversible bronchospasm.[38] Bronchodilators directly address only the last of those mechanisms. We consider bronchodilators for patients who are in moderate to severe distress with consistent wheeze and prolonged exhalation. In infants, we preferentially use racemic epinephrine over albuterol, given that both can improve reversible bronchospasm by binding to $\beta 2$ receptors and can improve clearance of mucus, but only racemic epinephrine treats airways edema by α receptor-mediated vasoconstriction. Although use of racemic epinephrine has not been shown to improve length of stay for inpatients, a small study in intubated patients showed that it can improve respiratory system resistance, and a more recent study supports that racemic epinephrine (in combination with corticosteroids) may reduce the duration of respiratory failure.[39-41] One downside is that secondary tachycardia limits the use of heart rate as a marker of overall stability.

In older children, we are more inclined to use albuterol, especially when historical factors (eg, eczema, recurrent wheeze, familial asthma) and acute signs (eg, hyperinflation) suggestive of an asthma-like phenotype are present. Some may give such children a diagnosis of reactive airway disease or critical asthma, while others would not entertain such diagnoses in children younger than 2 years. Overall, 10% to 60% of children with a clinical diagnosis of bronchiolitis have a history of wheezing.[42,43] This underlies a key issue in the field: inconsistent eligibility and diagnostic criteria make applicability of guidelines and research findings challenging. Notably, chest auscultation before and after albuterol does not identify children with improved respiratory system resistance reliably, and thus an albuterol trial should not be viewed as a gold standard.[44]

In 1 trial, corticosteroids improved outcomes in patients with atopy and a history of asthma in first-degree relatives, although subgroups in other trials with similar definitions were not similarly drug responsive.[45] Corticosteroids do not improve length of mechanical ventilation and can impair clearance of respiratory viruses, although the recent trial mentioned previously suggests possible efficacy when combined with bronchodilators.[46,47] In our experience, some children with a diagnosis of bronchiolitis show immediate improvements in respiratory status with albuterol and some children have a clinical status that seems to plateau and improve only after corticosteroids are initiated. A major gap in knowledge is how to identify these drug-responsive children at the bedside given that both albuterol (60%) and corticosteroids (33%) are used commonly in children with critical bronchiolitis, but with use varying markedly among centers (approximately 20%-90%).[48] Until reliable markers are available, we use these drugs in a small minority of patients with critical bronchiolitis, generally only in children with multiple points of evidence of an asthma-like phenotype.

When Should Antibiotics Be Administered?

In patients who require IMV, the rate of secondary bacterial pneumonia may be as high as 40%, and we have shown that empiric antibiotics are associated with improved outcomes.[49,50] Our current practice is to culture the lower respiratory tract promptly after intubation, start antibiotics, and treat with a full course of pathogen-specific antibiotics only if the culture analysis results are positive. It is imperative to collect the endotracheal sample soon after intubation because endotracheal tubes quickly can become colonized with bacteria that may not represent true infection. The amount of WBCs and the abundance of bacteria in the endotracheal sample may help to discern infection from colonization, but to our knowledge, no randomized trials have established thresholds for either variable that require treatment. We rarely use antibiotics in patients who are not intubated unless the evidence of bacterial pneumonia is very compelling.

How Should Fluids and Nutrition Be Provided?

Modest dehydration is common at presentation and should be treated with boluses of isotonic fluids; subsequently, we aim for euvolemia using isotonic fluids with dextrose and then to institute enteral nutrition as soon as deemed safe. Fluid overload is associated with unfavorable outcomes and should be avoided.[51] We initially withhold enteral feeding in children receiving noninvasive support. Two possible complications resulting from oral feeding are aspiration leading to worsening respiratory status and not having an empty stomach if intubation is needed. We have allowed select children receiving HFNC oxygenation to feed orally in our PICU for years with a very high safety profile, and our practice has become even more liberal over time.[52] Others have reported safely feeding children receiving CPAP and bilevel positive airway pressure.[53,54] We find that children who are 2 to 6 weeks of age or older do not aspirate at baseline and show interest in feeding can do so safely while receiving HFNC oxygenation. As soon as the child's respiratory trajectory has been established and progression to intubation is deemed unlikely, we offer the patient a bottle, usually starting with clear fluids and then advancing to formula or breast milk. For nearly all patients with critical bronchiolitis in our PICU, feedings are started while they are receiving HFNC oxygenation, often after only a few hours of monitoring. Doing so may improve vital signs and respiratory status.[54] We rarely use nasogastric feeds because babies are obligate nasal breathers and our approach to oral feeds enables early enteral nutrition in most children.

Case Report: Part 2

Baby J's respiratory status worsened over the subsequent hours. Racemic epinephrine administration showed no clear benefit. He was switched to CPAP at 7 cm H_2O and then bilevel positive airway pressure with a pressure support of 8 cm H_2O, and a dexmedetomidine infusion was started because of agitation. After 2 hours, his temperature was 37.6 °C, heart rate while calm was 170 beats/min, and respiratory rate was 60 breaths/min with

an Spo_2 of 91% with bilevel positive airway pressure with Fio_2 of 70%. Breath sounds were coarse bilaterally with decreased air entry, and work of breathing was moderately to severely increased even after bilevel positive airway pressure was increased to 20/10 cm H_2O.

How Is IMV Used in Bronchiolitis?

IMV is indicated for children with refractory hypoxemia, hypercarbia, respiratory distress, or a combination thereof, with noninvasive respiratory support at settings deemed maximal. Despite advancements in noninvasive support, IMV is needed for approximately 10% of patients with critical bronchiolitis and is associated with increased rates of morbidity.[22,55] Severe respiratory failure occurs most commonly in children with an underlying risk factor, such as younger age (eg, < 2-4 months), extreme prematurity, pulmonary hypertension, heart failure, trisomy 21, and neuromuscular disorders.[6] The absence of such a risk factor would make us consider a complication of bronchiolitis such as secondary bacterial pneumonia. We would intubate Baby J, given the degree of hypoxemia and distress, and also initiate antibiotics.

We typically initiate synchronized intermittent mandatory ventilation with a decelerating-flow pattern targeting a set tidal volume (ie, pressure-regulated volume control). We aim for plateau pressures of < 28 to 30 cm H_2O, Spo_2 of 90% to 96%, and pH of 7.25 to 7.35 to provide sufficient gas exchange while minimizing barotrauma, volutrauma, and excess oxygen exposure. Bronchiolitis was the most common specific disease in the Oxygenation in Paediatric Intensive Care Units (OXY-PICU) trial (approximately 37% of patients), in which children randomized to a lower Spo_2 target range achieved modestly improved outcomes compared with a liberal group whose actual Spo_2 generally was ≥ 96%.[56,57] Respiratory mechanics measured by the ventilator can show signs of restrictive or obstructive disease, or both.[58] Ventilation strategies need to be personalized from ventilator data, chest radiograph results, and physical examination findings. We find that some children benefit from high levels of positive end-expiratory pressure similar to pediatric ARDS (ie, restrictive disease with poor compliance, high plateau pressures, etc.), and some benefit from long expiratory times similar to critical asthma (ie, obstructive disease with prolonged exhalation, high peak inspiratory pressures with modest plateau pressures, etc). On average, patients with bronchiolitis are intubated for 6 days (interquartile range, 4-9 days).[49,50] We routinely use continuous fentanyl and dexmedetomidine to target mild levels of sedation. We find neuromuscular antagonists helpful in the youngest patients, whose small endotracheal tubes can be obstructed with secretions easily, which can lead to sudden, often recurrent, cardiorespiratory instability.

Multiple options exist for children who are unable to oxygenate or ventilate, or both, adequately with on conventional IMV. These include high-frequency oscillatory ventilation, high-frequency jet ventilation, high-frequency percussive ventilation, and extracorporeal membrane oxygenation. Another option is to tolerate further permissive hypercarbia (eg, pH of 7.15-7.25), permissive hypoxemia (Spo_2 of 88%-90%), high IMV settings (plateau pressure of 30-35 cm H_2O), or a combination thereof for a period to allow the chance for the child to recover without exposure to risks associated with nonconventional ventilation and extracorporeal membrane oxygenation.

We assess extubation readiness daily; perform spontaneous breathing trials when indicated; and extubate as early as possible to avoid continued risk of ventilator-induced lung injury, to reduce sedation exposure, and to facilitate removal of invasive catheters that risk infection and thrombosis. A unique indication for intubation in bronchiolitis is apnea, especially in neonates. In theory, caffeine could improve apnea, but a placebo-controlled trial did not show benefit, and we rarely use it.[59]

Conclusions

Critical bronchiolitis is a constellation of differing presentations and phenotypes. Each patient requires individualized treatment strategies to target the underlying pathophysiologic characteristics, although evidence-based ways to identify these drug-responsive phenotypes precisely at the bedside currently are lacking. In general, most patients can be treated with titrated HFNC oxygenation, early enteral nutrition as soon as risk of intubation is thought to be minimal, and close monitoring, with no need for any inhaled or systemic medications. Overuse of positive pressure ventilation (especially IMV) is to be avoided.

Financial/Nonfinancial Disclosures

The authors have reported to *CHEST Critical Care* the following: S. L. S. receives travel expenses from the Society of Critical Care Medicine. None declared (D. G. S.).

Acknowledgments

Additional information: The e-Table is available online under "Supplementary Data."

References

1. Hasegawa K, Tsugawa Y, Brown DF, Mansbach JM, Camargo CA Jr. Trends in bronchiolitis hospitalizations in the United States, 2000-2009. *Pediatrics*. 2013;132(1):28-36.
2. Heneghan JA, Rogerson C, Goodman DM, Hall M, Kohne JG, Kane JM. Epidemiology of pediatric critical care admissions in 43 United States children's hospitals, 2014-2019. *Pediatr Crit Care Med*. 2022;23(7):484-492.
3. Slain KN, Malay S, Shein SL. Hospital charges associated with critical bronchiolitis from 2009 to 2019. *Pediatr Crit Care Med*. 2022;23(3):171-180.
4. Betters KA, Gillespie SE, Miller J, Kotzbauer D, Hebbar KB. High flow nasal cannula use outside of the ICU; factors associated with failure. *Pediatr Pulmonol*. 2017;52(6):806-812.
5. Aguera M, Mele-Casas M, Molina MM, et al. Safety and effectiveness of bubble continuous positive airway pressure as respiratory support for bronchiolitis in a pediatric ward. *Eur J Pediatr*. 2022;181(12):4039-4047.
6. Slain K, Shein S. Acute viral bronchiolitis. In: Zimmerman JJ, Rotta AT, eds. *Fuhrman & Zimmerman's Pediatric Critical Care*. Elsevier; 2022:546-551.
7. Li Y, Wang X, Blau DM, et al. Global, regional, and national disease burden estimates of acute lower respiratory infections due to respiratory syncytial virus in children younger than 5 years in 2019: a systematic analysis. *Lancet*. 2022;399(10340):2047-2064.
8. Fischer M, Ngendahimana DK, Watson RS, Schwarz AJ, Shein SL. Cognitive, functional, and quality of life outcomes 6 months after mechanical ventilation for bronchiolitis: a secondary analysis of data from the Randomized Evaluation of Sedation Titration for Respiratory Failure Trial (RESTORE). *Pediatr Crit Care Med*. 2024;25(3):e129-e139.
9. van Benthum MV, van Dijk T, Maas-van Schaaijk NM, van Zwol A. Psychological problems in parents of children with bronchiolitis following paediatric intensive care unit (PICU) admission. *Acta Paediatr*. 2022;111(5):1054-1055.
10. Assathiany R, Sznajder M, Cahn-Sellem F, Dolard C, Werner A. Effects of infant bronchiolitis on family life. *Front Pediatr*. 2024;12:1343045.
11. de Sonnaville ESV, Knoester H, Terheggen-Lagro SWJ, Königs M, Oosterlaan J, van Woensel JBM. Long-term pulmonary outcomes in children mechanically ventilated for severe bronchiolitis. *Pediatr Crit Care Med*. 2022;23(10):801-811.
12. Ralston SL, Lieberthal AS, Meissner HC, et al. Clinical practice guideline: the diagnosis, management, and prevention of bronchiolitis. *Pediatrics*. 2014;134(5):e1474-e1502.
13. Shein SL, Slain K, Martinez Schlurmann N, Speicher R, Rotta AT. Hyponatremia and hypotonic intravenous fluids are associated with unfavorable outcomes of bronchiolitis admissions. *Hosp Pediatr*. 2017;7(5):263-270.
14. Feld LG, Neuspiel DR, Foster BA, et al; Subcommittee on Fluid and Electrolyte Therapy. Clinical practice guideline: maintenance intravenous fluids in children. *Pediatrics*. 2018;142(6):e20183083.
15. Milesi C, Baudin F, Durand P, et al. Clinical practice guidelines: management of severe bronchiolitis in infants under 12 months old admitted to a pediatric critical care unit. *Intensive Care Med*. 2023;49(1):5-25.
16. Friedman JN, Rieder MJ, Walton JM. Canadian Paediatric Society ACCDT, hazardous substances C. Bronchiolitis: recommendations for diagnosis, monitoring and management of children one to 24 months of age. *Paediatr Child Health*. 2014;19(9):485-498.
17. Paediatric Research in Emergency Departments International Collaborative Network A; Bronchiolitis guideline. Paediatric Research in Emergency Departments International Collaborative website. 2022. Accessed July 1, 2024. https://www.predict.org.au/bronchiolitis-guideline/
18. *Bronchiolitis in Children: Diagnosis and Management*. London: National Institute for Health and Care Excellence (NICE) 2021.
19. Polack FP, Stein RT, Custovic A. The syndrome we agreed to call bronchiolitis. *J Infect Dis*. 2019;220(2):184-186.
20. Dumas O, Mansbach JM, Jartti T, et al. A clustering approach to identify severe bronchiolitis profiles in children. *Thorax*. 2016;71(8):712-718.
21. Rodriguez-Martinez CE, Nino G, Castro-Rodriguez JA, Perez GF, Sossa-Briceno MP, Buendia JA. Cost-effectiveness analysis of phenotypic-guided versus guidelines-guided bronchodilator therapy in viral bronchiolitis. *Pediatr Pulmonol*. 2021;56(1):187-195.
22. Pelletier JH, Maholtz DE, Hanson CM, et al. Respiratory support practices for bronchiolitis in the pediatric intensive care unit. *JAMA Netw Open*. 2024;7(5):e2410746.
23. Alexander EC, Wadia T, Ramnarayan P. Effectiveness of high flow nasal cannula (HFNC) therapy compared to standard oxygen therapy (SOT) and continuous positive airway pressure (CPAP) in bronchiolitis. *Paediatr Respir Rev*. 2024;52:3-8.
24. Rubin S, Ghuman A, Deakers T, Khemani R, Ross P, Newth CJ. Effort of breathing in children receiving high-flow nasal cannula. *Pediatr Crit Care Med*. 2014;15(1):1-6.
25. Slain KN, Shein SL, Rotta AT. The use of high-flow nasal cannula in the pediatric emergency department. *J Pediatr (Rio J)*. 2017;93(suppl 1):36-45.
26. Franklin D, Babl FE, Schlapbach LJ, et al. A randomized trial of high-flow oxygen therapy in infants with bronchiolitis. *N Engl J Med*. 2018;378(12):1121-1131.
27. Garland H, Gunz AC, Miller MR, Lim RK. High-flow nasal cannula implementation has not reduced intubation rates for bronchiolitis in Canada. *Paediatr Child Health*. 2021;26(4):e194-e198.
28. Milesi C, Pierre AF, Deho A, et al. A multicenter randomized controlled trial of a 3-L/kg/min versus 2-L/kg/min high-flow nasal cannula flow rate in young infants with severe viral bronchiolitis (TRAMONTANE 2). *Intensive Care Med*. 2018;44(11):1870-1878.
29. Milesi C, Requirand A, Douillard A, et al. Assessment of peak inspiratory flow in young infants with acute viral bronchiolitis: physiological basis for initial flow setting in patients supported with high-flow nasal cannula. *J Pediatr*. 2021;231:239-245.e231.
30. Weiler T, Kamerkar A, Hotz J, Ross PA, Newth CJL, Khemani RG. The relationship between high flow nasal cannula flow rate and effort of breathing in children. *J Pediatr*. 2017;189:66-71.e63.
31. Shein SL, Slain KN, Rotta AT, Milesi C, Cambonie G. High-flow nasal cannula flow rate in young infants with severe viral bronchiolitis: the question is still open. *Intensive Care Med*. 2019;45(1):134-135.
32. Milesi C, Essouri S, Pouyau R, et al. High flow nasal cannula (HFNC) versus nasal continuous positive airway pressure (nCPAP) for the initial respiratory management of acute viral bronchiolitis in young infants: a multicenter randomized controlled trial (TRAMONTANE study). *Intensive Care Med*. 2017;43(2):209-216.
33. Ramnarayan P, Richards-Belle A, Drikite L, et al. Effect of high-flow nasal cannula therapy vs continuous positive airway pressure therapy on liberation from respiratory support in acutely ill children admitted to pediatric critical care units: a randomized clinical trial. *JAMA*. 2022;328(2):162-172.
34. Coon ER, Stoddard G, Brady PW. Intensive care unit utilization after adoption of a ward-based high-flow nasal cannula protocol. *J Hosp Med*. 2020;15(6):325-330.
35. Riese J, Porter T, Fierce J, Riese A, Richardson T, Alverson BK. Clinical outcomes of bronchiolitis after implementation of a general ward high flow nasal cannula guideline. *Hosp Pediatr*. 2017;7(4):197-203.
36. Byrd C, Noelck M, Kerns E, et al. Multicenter quality collaborative to reduce overuse of high-flow nasal cannula in bronchiolitis. *Pediatrics*. 2024;153(5):e2023063509.
37. Maue DK, Ealy A, Hobson MJ, et al. Improving outcomes for bronchiolitis patients after implementing a high-flow nasal cannula holiday and standardizing discharge criteria in a PICU. *Pediatr Crit Care Med*. 2023;24(3):233-242.
38. Oymar K, Skjerven HO, Mikalsen IB. Acute bronchiolitis in infants, a review. *Scand J Trauma Resusc Emerg Med*. 2014;22:23.
39. Hartling L, Bialy LM, Vandermeer B, et al. Epinephrine for bronchiolitis. *Cochrane Database Syst Rev*. 2011;(6):CD003123.

40. Levin DL, Garg A, Hall LJ, Slogic S, Jarvis JD, Leiter JC. A prospective randomized controlled blinded study of three bronchodilators in infants with respiratory syncytial virus bronchiolitis on mechanical ventilation. *Pediatr Crit Care Med*. 2008;9(6):598-604.

41. Gelbart B, McSharry B, Delzoppo C, et al. Pragmatic randomized trial of corticosteroids and inhaled epinephrine for bronchiolitis in children in intensive care. *J Pediatr*. 2022;244:17-23.e11.

42. Megalaa R, Perez GF, Kilaikode-Cheruveettara S, Kotwal N, Rodriguez-Martinez CE, Nino G. Clinical definition of respiratory viral infections in young children and potential bronchiolitis misclassification. *J Invest Med*. 2018;66(1):46-51.

43. Sala KA, Moore A, Desai S, Welch K, Bhandari S, Carroll CL. Factors associated with disease severity in children with bronchiolitis. *J Asthma*. 2015;52(3):268-272.

44. Schramm CM, Sala KA, Carroll CL. Clinical examination does not predict response to albuterol in ventilated infants with bronchiolitis. *Pediatric Crit Care Med*. 2017;18(1):e18-e23.

45. Alansari K, Sakran M, Davidson BL, Ibrahim K, Alrefai M, Zakaria I. Oral dexamethasone for bronchiolitis: a randomized trial. *Pediatrics*. 2013;132(4):e810-e816.

46. Buckingham SC, Jafri HS, Bush AJ, et al. A randomized, double-blind, placebo-controlled trial of dexamethasone in severe respiratory syncytial virus (RSV) infection: effects on RSV quantity and clinical outcome. *J Infect Dis*. 2002;185(9):1222-1228.

47. van Woensel JB, van Aalderen WM, de Weerd W, et al. Dexamethasone for treatment of patients mechanically ventilated for lower respiratory tract infection caused by respiratory syncytial virus. *Thorax*. 2003;58(5):383-387.

48. Pierce HC, Mansbach JM, Fisher ES, et al. Variability of intensive care management for children with bronchiolitis. *Hosp Pediatr*. 2015;5(4):175-184.

49. Karsies T, Shein SL, Diaz F, et al; with the Bronchiolitis And COdetectioN (BACON) Study Investigators; for the Bronchiolitis Subgroup of the Pediatric Acute Lung Injury and Sepsis Investigators Network and the Red Colaborativa Pediátrica de Latinoamérica Network. Prevalence of bacterial codetection and outcomes for infants intubated for respiratory infections. *Pediatr Crit Care Med*. 2024;25(7):609-620.

50. Shein SL, Kong M, McKee B, O'Riordan M, Toltzis P, Randolph AG. Antibiotic prescription in young children with respiratory syncytial virus-associated respiratory failure and associated outcomes. *Pediatr Crit Care Med*. 2019;20(2):101-109.

51. Flores-Gonzalez JC, Valladares CM, Yun Castilla C, et al. Association of fluid overload with clinical outcomes in critically ill children with bronchiolitis: Bronquiolitis en la Unidad de Cuidados Intensivos Pediatricos (BRUCIP) Study. *Pediatr Crit Care Med*. 2019;20(3):e130-e136.

52. Slain KN, Martinez-Schlurmann N, Shein SL, Stormorken A. Nutrition and high-flow nasal cannula respiratory support in children with bronchiolitis. *Hosp Pediatr*. 2017;7(5):256-262.

53. Lenihan A, Ramos V, Nemec N, et al. A retrospective analysis of feeding practices and complications in patients with critical bronchiolitis on non-invasive respiratory support. *Children (Basel)*. 2021;8(5):410.

54. Sochet AA, Nunez M, Wilsey MJ, Morrison JM, Bessone SK, Nakagawa TA. Enteral nutrition improves vital signs in children with bronchiolitis on noninvasive ventilation. *Hosp Pediatr*. 2021;11(2):135-143.

55. Shein SL, Slain KN, Clayton JA, McKee B, Rotta AT, Wilson-Costello D. Neurologic and functional morbidity in critically ill children with bronchiolitis. *Pediatr Crit Care Med*. 2017;18(12):1106-1113.

56. Peters MJ, Gould DW, Ray S, et al. Conservative versus liberal oxygenation targets in critically ill children (Oxy-PICU): a UK multicentre, open, parallel-group, randomised clinical trial. *Lancet*. 2024;403(10424):355-364.

57. Shein SL, Karsies T. Conservative versus liberal oxygenation targets for children admitted to PICU. *Lancet*. 2024;403(10424):326-327.

58. Cruces P, Gonzalez-Dambrauskas S, Quilodran J, et al. Respiratory mechanics in infants with severe bronchiolitis on controlled mechanical ventilation. *BMC Pulm Med*. 2017;17(1):129.

59. Alansari K, Toaimah FH, Khalafalla H, El Tatawy LA, Davidson BL, Ahmed W. Caffeine for the treatment of apnea in bronchiolitis: a randomized trial. *J Pediatr*. 2016;177:204-211.e203.