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Bronchiolitis: Diagnostic Challenges, Empirical Antibiotic Choices, And Stewardship

Dr. Ayah Mohammed Eshbee[1], Dr. Fatema Nadem[1], Dr. Abdulah Mohammed Abd Alhamed Abou Kaff[1], Dr. Abdalghani Fuad Mukhalalati[2]

[1]Department of Pediatrics, Zawia Medical Center, Az Zawiyah, Libya.

[2]Department of Internal Medicine, Alexandria Faculty of Medicine, Alexandria, Libya.

Corresponding Author: Dr. Ayah Mohamed Eshbeel, Ayahalmo@outlook.com

Abstract: Bronchiolitis remains the leading cause of lower respiratory tract infection in infants, posing significant diagnostic and management challenges for pediatric clinicians. This narrative review synthesizes current evidence regarding the epidemiological burden, clinical presentation, diagnostic dilemmas, and evolving management strategies, with a particular focus on empirical antibiotic choices and antimicrobial stewardship. Despite its predominantly viral etiology, bacterial coinfection is a persistent concern, often leading to inappropriate antibiotic prescribing. We explore the utility of diagnostic tools, the role of biomarkers, and the controversies surrounding pharmacological interventions such as bronchodilators and corticosteroids. Furthermore, the review addresses the impact of the post-COVID-19 pandemic epidemiology, the emergence of novel preventive strategies like nirsevimab, and the specific considerations for high-risk populations. By highlighting key clinical takeaways, identifying practice gaps, and outlining future research priorities, this article aims to optimize diagnostic approaches, promote judicious antibiotic use, and enhance overall care for infants with bronchiolitis.

Keywords: Bronchiolitis, Infants, Respiratory syncytial virus (RSV), Bacterial coinfection, Empirical antibiotic therapy, Antimicrobial stewardship, Nirsevimab, Clinical management

Introduction

Bronchiolitis, primarily caused by respiratory syncytial virus (RSV), is the most common lower respiratory tract infection in infants and young children, leading to substantial morbidity and healthcare utilization worldwide [1]. Annually, it accounts for millions of outpatient visits, emergency department presentations, and hospitalizations, placing a significant epidemiological burden on healthcare systems [1, 2]. The clinical relevance of bronchiolitis extends beyond acute illness, with potential long-term sequelae such as recurrent wheezing and asthma [15].

Despite its prevalence, the diagnosis and management of bronchiolitis present ongoing challenges. The clinical picture can overlap with other pediatric respiratory conditions, and the fear of missing a bacterial coinfection often drives empirical antibiotic prescribing, contributing to antimicrobial resistance [7, 10, 11]. This narrative review aims to provide a comprehensive overview of bronchiolitis, addressing its epidemiological burden, clinical relevance, diagnostic challenges, empirical antibiotic choices, and the critical role of antimicrobial stewardship. We will also explore recent advancements in prevention and management, as well as areas of ongoing controversy and future research.

Methods

This article presents a narrative review of the current literature on bronchiolitis in pediatric populations. A comprehensive search strategy was employed across several electronic databases, including PubMed, Cochrane Library, and Embase. Keywords used for the search included, but were not limited to: "bronchiolitis," "pediatric," "infant," "diagnosis," "management," "antibiotics," "antimicrobial stewardship," "RSV," "epidemiology," "pathophysiology," "high-flow nasal cannula," "bronchodilators," "corticosteroids," "nirsevimab," "palivizumab," "bacterial coinfection," "complications," and "special populations." The search was conducted for articles published up to July 2026, with a particular emphasis on landmark studies, recent meta-analyses, and authoritative clinical practice guidelines from organizations such as the American Academy of Pediatrics (AAP) [1], National Institute for Health and Care Excellence (NICE) [2], and the World Health Organization (WHO) [3]. Inclusion criteria focused on studies and reviews relevant to the specified themes, while exclusion criteria included non-English language articles and those not directly addressing pediatric bronchiolitis. This narrative review synthesizes the findings from the identified literature to provide a broad perspective on the topic.

Pathophysiology

Bronchiolitis is characterized by acute inflammation, edema, and necrosis of the small airways (bronchioles), leading to increased mucus production and cellular debris that obstruct airflow [17]. The primary etiological agent is RSV, responsible for 70-80% of cases, with other viruses such as rhinovirus, parainfluenza virus, and adenovirus also contributing [1].

The pathogenesis begins with viral replication in the ciliated epithelial cells of the respiratory tract. This triggers a robust host immune response, involving the recognition of viral components by toll-like receptors (TLRs) and the subsequent release of pro-inflammatory cytokines and chemokines, including interleukin-6 (IL-6), interleukin-8 (IL-8), and tumor necrosis factor-alpha (TNF-α) [15, 17]. This inflammatory cascade leads to the recruitment of immune cells, particularly neutrophils, to the site of infection. The resulting inflammation, coupled with a shift towards a Th2 and Th17 immune profile, contributes to the characteristic airway obstruction [16, 17]. The sloughing of necrotic epithelial cells and the formation of mucus plugs further exacerbate the narrowing of the bronchioles, leading to air trapping, atelectasis, and ventilation-perfusion mismatch, ultimately manifesting as respiratory distress [17].

Epidemiology

The epidemiology of bronchiolitis has historically been characterized by predictable seasonal outbreaks, typically during the winter months in temperate climates [9]. However, the COVID-19 pandemic significantly altered these patterns. During the initial phases of the pandemic, public health measures such as lockdowns, mask-wearing, and social distancing led to a dramatic decrease in RSV and other respiratory viral infections [1]. Following the relaxation of these measures, many regions experienced unusual, off-season surges in bronchiolitis cases, often with increased severity, attributed to an "immunity debt" in the infant population [1]. This post-COVID-19 epidemiological shift highlights the dynamic nature of respiratory viral infections and the importance of ongoing surveillance.

Clinical Presentation

Bronchiolitis typically affects infants under two years of age, with a peak incidence between two and six months [1]. The clinical presentation usually begins with symptoms of an upper respiratory tract infection, such as rhinorrhea, nasal congestion, and a mild cough, which progress over several days to lower respiratory tract involvement. Key signs and symptoms include tachypnea, wheezing, crackles (rales) on auscultation, nasal flaring, retractions (subcostal, intercostal, and suprasternal), and grunting [1]. Fever may be present but is often low-grade. In severe cases, infants may exhibit signs of respiratory distress, including cyanosis, apnea, and poor feeding, necessitating hospitalization [1]. Dehydration is a common complication due to increased respiratory effort and reduced oral intake.

Diagnosis

The diagnosis of bronchiolitis is primarily clinical, based on a thorough history and physical examination [1, 21]. Laboratory tests and imaging studies are generally not recommended for routine diagnosis in otherwise healthy infants with typical clinical presentations, as they rarely alter management and can lead to unnecessary interventions and increased healthcare costs [21].

Diagnostic Challenges

Diagnostic challenges arise when differentiating bronchiolitis from other conditions that present with similar respiratory symptoms, such as bacterial pneumonia, acute otitis media (AOM), or early asthma [7]. The presence of bacterial coinfection, though uncommon, is a significant concern that often drives diagnostic workups and empirical antibiotic use [7, 10]. Studies have shown that bacterial coinfection rates in bronchiolitis are low, typically around 1-2% for serious bacterial infections (SBI) like bacteremia or meningitis, with slightly higher rates for urinary tract infections (UTIs) [28, 29, 30].

Role of Biomarkers and Viral Testing

Biomarkers such as C-reactive protein (CRP) and procalcitonin (PCT) have been investigated for their utility in identifying bacterial coinfection in bronchiolitis. However, their routine use is not recommended due to limited specificity and sensitivity in distinguishing viral from bacterial infections in this context [7]. While elevated levels might suggest a bacterial process, they are not definitive and should be interpreted cautiously within the overall clinical picture. Viral testing, typically via multiplex polymerase chain reaction (PCR) panels, can identify the specific viral pathogen. While useful for epidemiological surveillance and cohorting patients, routine viral testing does not generally change acute management for most infants with bronchiolitis and is not universally recommended [21]. However, identifying RSV can reinforce the viral diagnosis and potentially reduce unnecessary antibiotic use by reassuring clinicians that a bacterial infection is less likely [10].

Management

The cornerstone of bronchiolitis management is supportive care, focusing on maintaining adequate hydration and respiratory support [1, 21].

Non-Pharmacological Management

Hydration: Infants with bronchiolitis are at risk of dehydration due to increased insensible fluid losses from tachypnea and decreased oral intake. Oral rehydration is preferred, but intravenous fluids may be necessary for infants with significant respiratory distress or poor feeding [1].

Airway Clearance: Nasal suctioning is crucial for clearing secretions and improving airflow, especially in young infants who are obligate nasal breathers [1]. Humidified oxygen may also be beneficial.

Oxygen Therapy: Supplemental oxygen is indicated for infants with hypoxemia (oxygen saturation <90-92%) [1, 23]. High-flow nasal cannula (HFNC) therapy has gained widespread use and has been shown to reduce the risk of treatment escalation (e.g., need for mechanical ventilation) compared to standard oxygen therapy, although it may not significantly reduce the length of hospital stay or ICU admission rates [4, 12, 13]. The decision between HFNC and standard oxygen therapy often depends on institutional protocols and patient severity.

Pharmacological Management

Despite extensive research, pharmacological interventions have largely been found to be ineffective for routine bronchiolitis and are generally not recommended by major guidelines [1, 2].

Bronchodilators: Beta-2 agonists (e.g., albuterol) are not routinely recommended due to lack of consistent evidence of benefit and potential for adverse effects [25]. A trial of bronchodilator may be considered in infants with a history of wheezing or a strong family history of asthma, but treatment should be discontinued if no clear clinical improvement is observed [1].

Corticosteroids: Systemic corticosteroids have not been shown to improve outcomes in bronchiolitis and are not recommended [26].

Hypertonic Saline: Inhaled hypertonic saline has been studied as a mucolytic agent, but meta-analyses have not demonstrated consistent benefits in reducing hospital stay or severity of illness [24]. Its routine use is not recommended.

Antivirals: Antiviral medications are generally not recommended for routine bronchiolitis, as the disease is typically self-limiting. Ribavirin may be considered in severe cases in immunocompromised infants, but its use is limited [1].

Empirical Antibiotic Choices and Stewardship

Given the predominantly viral etiology of bronchiolitis, antibiotics are not indicated unless there is strong evidence of bacterial coinfection [1, 10]. However, inappropriate antibiotic prescribing remains a significant issue, driven by diagnostic uncertainty and the desire to prevent potential bacterial complications [7, 11].

Challenges in Antibiotic Stewardship

The main challenges in antibiotic stewardship for bronchiolitis include:

- **Difficulty in distinguishing viral from bacterial infections:** Clinical signs and symptoms of viral bronchiolitis can mimic those of bacterial infections, leading to diagnostic uncertainty.
- **Fear of missing serious bacterial infection (SBI):** Clinicians may err on the side of caution and prescribe antibiotics to avoid adverse outcomes from undetected bacterial infections.
- **Lack of rapid and reliable diagnostic tests:** Current diagnostic tools for bacterial coinfection have limitations, contributing to empirical antibiotic use.

Empirical Antibiotic Choices for Suspected Bacterial Coinfection

When bacterial coinfection is strongly suspected (e.g., persistent high fever, focal infiltrates on chest X-ray, positive bacterial cultures), empirical antibiotic therapy should be initiated. The choice of antibiotic depends on the suspected site of infection and local epidemiology.

- **Pneumonia:** For suspected bacterial pneumonia, amoxicillin or ampicillin are often first-line agents, targeting common pathogens like *Streptococcus pneumoniae* [20]. For infants under 3 months or those who are unvaccinated, broader coverage with cefotaxime or ceftriaxone may be considered [20].
- **Urinary Tract Infection (UTI):** If a UTI is suspected, empirical treatment often involves antibiotics such as cefotaxime or gentamicin, pending urine culture results [29].
- **Acute Otitis Media (AOM):** AOM is a common bacterial coinfection in infants with bronchiolitis. Amoxicillin is the preferred first-line treatment [1].

Strategies for Antimicrobial Stewardship

Effective antimicrobial stewardship programs are crucial to reduce inappropriate antibiotic use in bronchiolitis. Key strategies include:

- **Education:** Educating clinicians on the viral nature of bronchiolitis and the low incidence of bacterial coinfection.
- **Clinical Guidelines:** Implementing and adhering to evidence-based clinical guidelines that discourage routine antibiotic use [1, 2, 10].

- **Diagnostic Algorithms:** Developing and utilizing diagnostic algorithms that help differentiate viral bronchiolitis from bacterial infections, guiding appropriate testing and antibiotic decisions.
- **Rapid Viral Testing:** While not routinely recommended for management, rapid viral testing can help reinforce a viral diagnosis and reduce antibiotic prescribing [10].
- **Audits and Feedback:** Regular audits of antibiotic prescribing practices and providing feedback to clinicians can promote adherence to stewardship principles [10].

Complications

While most infants recover fully from bronchiolitis, some may experience complications. The most common acute complications include respiratory failure requiring mechanical ventilation, apnea (especially in premature infants), and dehydration [1]. Less common but serious complications include secondary bacterial infections such as pneumonia, otitis media, and, rarely, sepsis [7]. Long-term complications can include recurrent wheezing and an increased risk of developing asthma in later childhood [15].

Special Populations

Certain infant populations are at higher risk for severe bronchiolitis and associated complications [9]. These include:

- **Premature Infants:** Especially those born before 37 weeks gestation, who have underdeveloped lungs and immune systems [9].
- **Infants with Chronic Lung Disease (CLD):** Such as bronchopulmonary dysplasia, which compromises respiratory function [9].
- **Infants with Congenital Heart Disease (CHD):** Particularly those with hemodynamically significant lesions, who have reduced cardiopulmonary reserve [9, 18].
- **Immunocompromised Infants:** Including those with primary immunodeficiencies or those receiving immunosuppressive therapy.
- **Infants with Neuromuscular Disorders or Down Syndrome:** These conditions can impair airway clearance and increase susceptibility to severe respiratory infections.

For these high-risk groups, preventive strategies are particularly important. Palivizumab, a monoclonal antibody, has historically been used for passive immunization against RSV in selected high-risk infants [1]. More recently, nirsevimab, a long-acting monoclonal antibody, has emerged as a significant advancement, offering broader and more sustained protection against RSV for a full RSV season with a single dose [5, 6, 14]. This represents a paradigm shift in RSV prevention, especially for vulnerable populations.

Controversies and Evidence Gaps

Several areas in bronchiolitis management remain controversial and highlight evidence gaps.

Bronchodilators and Corticosteroids: Despite clear guideline recommendations against their routine use, bronchodilators and corticosteroids are still frequently prescribed [25, 26]. This practice often stems from the perceived benefit in individual cases or the difficulty in differentiating bronchiolitis from asthma. Further research focusing on specific patient phenotypes that might benefit from these therapies is needed.

High-Flow Nasal Cannula (HFNC): While HFNC has demonstrated efficacy in reducing treatment escalation, its precise role and optimal application, particularly in comparison to other forms of non-invasive respiratory support like CPAP, continue to be debated [12]. Studies are ongoing to define the patient populations most likely to benefit and to standardize HFNC protocols.

Biomarkers for Bacterial Coinfection: The search for reliable biomarkers to accurately identify bacterial coinfection in bronchiolitis remains an active area of research. Improved diagnostic tools could significantly reduce unnecessary antibiotic exposure.

Long-term Outcomes: While the association between bronchiolitis and subsequent recurrent wheezing and asthma is well-established, the underlying mechanisms and potential interventions to mitigate these long-term sequelae require further investigation.

Conclusion

Bronchiolitis continues to be a major cause of infant morbidity, presenting persistent diagnostic and management challenges. The predominantly viral etiology underscores the importance of judicious antibiotic use and robust antimicrobial stewardship programs. Clinical diagnosis, supportive care, and appropriate oxygen therapy remain the cornerstones of management, with limited roles for pharmacological interventions. The post-COVID-19 era has highlighted dynamic epidemiological shifts, while the advent of nirsevimab offers a promising new avenue for RSV prevention, particularly in high-risk populations. Future research should focus on refining diagnostic strategies for bacterial coinfection, optimizing respiratory support modalities, and elucidating the long-term respiratory consequences of bronchiolitis. By addressing these practice gaps and prioritizing evidence-based care, pediatric clinicians can enhance outcomes and promote antimicrobial stewardship in the management of this common infant illness.

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