Pneumonia in healthy Canadian children and youth: Practice points for management

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N Le Saux, JL Robinson; Canadian Paediatric Society, Infectious Diseases and Immunization Committee. Pneumonia in healthy Canadian children and youth: Practice points for management. Paediatr Child Health 2011;16(7):417-420.

Although immunization has decreased the incidence of bacterial pneumonia in vaccinated children, pneumonia remains common in healthy children. Unless it is totally impractical, a chest radiograph should be performed to confirm the diagnosis of pneumonia. Factors such as age, vital signs and other measures of illness severity are critical in the decision regarding whether to admit a patient to hospital. Because *Streptococcus pneumoniae* continues to be the most common cause of bacterial pneumonia in children, prescribing amoxicillin or ampicillin for seven to 10 days remains the mainstay of empirical therapy for non-severe pneumonia. If improvement does not occur, consideration should be given to searching for complications (empyema or lung abscess). Routine chest radiographs at the end of therapy are not recommended unless clinically indicated.

Key Words: *Antimicrobial therapy; Bacterial pneumonia; Viral pneumonia*

La pneumonie chez les enfants et adolescents canadiens en santé : des points de pratique de la prise en charge

La vaccination a réduit l'incidence de pneumonie bactérienne chez les enfants vaccinés, mais la pneumonie demeure courante chez les enfants en santé. À moins que ce soit tout à fait irréalisable, il faudrait effectuer une radiographie pulmonaire pour confirmer le diagnostic de pneumonie. Des facteurs comme l'âge, les signes vitaux et d'autres mesures de gravité de la maladie sont essentiels dans la décision d'hospitaliser ou non un patient. Puisque le *Streptococcus pneumoniae* continue d'être la principale cause de pneumonie bactérienne chez les enfants, la prescription d'amoxicilline ou d'ampicilline pendant sept à dix jours constitue le principal traitement empirique d'une forme non sévère de la pneumonie. Si on n'observe pas d'amélioration, il faut envisager des complications (empyème ou abcès pulmonaire). Il n'est pas recommandé de procéder à une radiographie pulmonaire systématique à la fin du traitement, à moins d'une indication clinique.

Most physicians who care for children and youth have had experience in managing acute pneumonia. The WHO has estimated that in developed countries, one in 20 children younger than five years of age will contract pneumonia each year (1,2). Pneumococcal conjugate vaccines have been shown to decrease radiologically proven pneumonia admission rates by an average of 27% (3-6).

The present practice point focuses on the current diagnosis and management of uncomplicated acute community-acquired pneumonia in healthy immunized children with no underlying pulmonary pathology aside from mild reactive airways disease. The practice point does not apply to persistent (chronic) pneumonia syndromes (with symptoms for more than two weeks), aspiration pneumonia or recurrent pneumonias, or those associated with chronic medical problems such as immunodeficiency, because these pneumonias may be caused by different pathogens or require more extensive investigation.

DEFINITION AND HOST RISK FACTORS

Pneumonia is an acute inflammation of the parenchyma of the lower respiratory tract caused by a microbial pathogen. Bacterial infections are usually primary but, occasionally, viral respiratory tract infections such as influenza can increase the subsequent risk of bacterial pneumonias (7). In uncomplicated pneumonia, there is no evidence of empyema (pus in the pleural space), a lung abscess or a necrotic lung.

ETIOLOGY

The most common causes of pneumonia in infants and preschool children are viruses that usually, but not exclusively, circulate in winter (eg, respiratory syncytial virus, influenza, parainfluenza virus and human metapneumovirus). Viruses as a sole cause of pneumonia are less common in older children with the exception of influenza (8).

Among bacteria, *Streptococcus pneumoniae* continues to be the most significant pathogen in children of all ages (9). Group A streptococcal pneumonia is much less common. Although *Staphylococcus aureus* is not a common cause of paediatric pneumonia, it has been increasingly encountered in communities where methicillin-resistant *Staphylococcus aureus* is prevalent. *Haemophilus influenzae* type b has almost disappeared because of vaccination. *Mycoplasma pneumoniae* and *Chlamydophila pneumoniae* are more common causes of pneumonia among school-age children, but they occasionally cause pneumonia in younger children (10,11).

SYMPTOMS AND SIGNS OF ACUTE PNEUMONIA

The symptoms of pneumonia may be nonspecific, especially in infants and younger children. Acute onset of fever, cough, difficulty breathing, poor feeding or vomiting, and lack of interest in normal activities are common. Chest or abdominal pain may be a prominent feature. Abrupt onset of rigors favours a bacterial cause. A significant, persistent cough may predominate in pneumonia caused by M *pneumoniae*. During influenza season, consider influenza, with or without a secondary bacterial component, as a cause of pneumonia.

Children typically experience fever and tachypnea (determined by counting the respiratory rate for 60 s in a calm state; see Table 1). Indrawing, retractions and/or a tracheal tug will indicate respiratory distress (dyspnea) (12). Decreased oxygen saturation

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TABLE 1
Age-specific criteria for tachypnea

Age	Approximate normal respiratory rates (breaths/min)	Upper limit that should be used to define tachypnea (breaths/min)
<2 months	34–50	60
2–12 months	25–40	50
1–5 years	20–30	40
>5 years	15–25	30

Adapted from reference 14

indicates hypoxemia and should be measured in all hospital settings. Cyanosis will only be evident with very severe hypoxemia. Normal oxygen saturation does not exclude pneumonia, especially early in the course of the illness.

Physical signs suggesting consolidation include dullness to percussion, increased tactile fremitus, reduced normal vesicular breath sounds and increased bronchial breath sounds – all of which can be difficult to detect in young children. The presence of wheezing should suggest the possibility that radiographic changes may be due to atelectasis and mucous plugging from asthma or bronchiolitis rather than pneumonia. Signs of an effusion are dullness to percussion, decreased tactile fremitus, and decreased or absent breath sounds. There may be associated signs of dehydration and/or sepsis (12).

INVESTIGATIONS

Imaging

Pneumonia is overdiagnosed in the absence of radiological confirmation. Radiological confirmation is encouraged whenever possible to support the clinical diagnosis and may be useful if the child subsequently deteriorates. Poorly defined nodules and patchy areas of opacity with variable hyperinflation and without effusion are more indicative of a viral etiology (13). Lobar or segmental consolidation with or without pleural effusions is suggestive of bacterial pneumonia due to *S pneumoniae*, group A streptococcus and, less commonly, *S aureus*. The atypical pathogens, *M pneumoniae* or *C pneumoniae*, classically produce focal infiltrates that appear to be more extensive than the clinical findings would suggest.

Detection of the pathogen

Determining the etiology of pneumonia is difficult in children because few children are bacteremic, and most cannot provide a sputum sample. If adequate sputum is available, it should be sent for Gram staining and subsequent culture (14). Culture of pleural fluid is suggested if it can be sampled. Additional invasive or molecular testing should be pursued if the child fails to improve or worsens on therapy.

Routine viral testing of nasopharyngeal secretions is usually not indicated for outpatients with mild or moderate illness. Admitted children who have possible viral pneumonia should undergo viral

TABLE 2
Guidelines for empirical antimicrobial therapy for previously healthy children three months to 17 years of age with community-acquired, radiologically proven pneumonia of suspected bacterial etiology

Step 1: Assess severity and features of pneumonia*:

A. Most cases of nonsevere pneumonia → high-dose amoxicillin PO or ampicillin IV

B. Nonsevere pneumonia with primary features of atypical pneumonia (subacute onset, prominent cough, minimal leukocytosis and a nonlobar infiltrate, usually in a school-age child) → clarithromycin PO or azithromycin PO

C. Severe pneumonia → ceftriaxone IM/IV or cefotaxime IV plus clarithromycin PO or azithromycin PO/IV

Step 2: Assess whether child has proven or clinically suspected influenza plus evidence of secondary bacterial infection†, consider adding an antiviral for influenza and use the following instead of the antibiotics from step 1†:

A. Nonsevere pneumonia → amoxicillin/clavulanate PO or cefuroxime IV

B. Severe pneumonia → ceftriaxone IM/IV or cefotaxime IV plus clarithromycin PO or azithromycin PO/IV. Some experts advise also adding cloxacillin IV

Step 3: If the child also has a pleural effusion‡:

A. Small effusion → follow carefully for clinical deterioration and use antibiotics as directed in steps 1 and 2

B. Moderate to large effusion → consider pleural tap‡. Treat with ceftriaxone or cefotaxime instead of antibiotics in steps 1 and 2. Some experts recommend adding clindamycin

Step 4: If the child has features that indicate pneumonia could be due to methicillin-resistant *Staphylococcus aureus* (MRSA)§, add vancomycin or linezolid to the antibiotics chosen after steps 1, 2 and 3

*For penicillin-allergic children, see text under 'Management'. Nonsevere pneumonia does not require hospital admission or requires admission and minimal supplemental oxygen (fraction of inspired oxygen lower than 0.30) and is in minimal respiratory distress. Severe pneumonia requires significant supplemental oxygen, patient is in moderate respiratory distress and may require intensive care. *The primary goal is to offer good coverage for pneumococcus. Ceftriaxone or cefotaxime may offer better coverage than amoxicillin or ampicillin for penicillin-resistant pneumococcus (although this remains controversial), and offer improved coverage for* Haemophilus influenzae *and* Moraxella catarrhalis*, but these are rare causes of pneumonia in healthy, immunized children. Clarithromycin and azithromycin do not always cover pneumococcus, so they should be reserved for children with suspected atypical pneumonia. Additionally, in patients who fail to improve after 48 h of therapy with a beta lactam alone (penicillin such as ampicillin or cephalosporins), one should first rule out an empyema and then consider adding clarithromycin or azithromycin for atypical pneumonia; †One would suspect secondary bacterial infection if the initial chest x-ray showed significant airspace consolidation or pleural fluid, or the child experienced clinical improvement followed by clinical and radiographic deterioration. Antibiotics should offer good coverage for pneumococcus, methicillin-susceptible* Staphylococcus aureus *(MSSA) and group A streptococcus. Some experts recommend adding cloxacillin because it will offer additional optimal coverage for MSSA; ‡The decision to attempt a diagnostic or therapeutic tap of an effusion must be made after considering possible risks and benefits; size, location, and radiological, surgical and diagnostic resources must be considered. If the fluid is serous, management is clinical follow-up. If the fluid is exudative (pH lower than 7.20, glucose level lower than 2.2 mmol/L, lactose dehydrogenase level greater than 1000 U/L, significant white blood cell count, cloudy appearance or bacteria growth), the child likely has an empyema and ongoing drainage should be arranged, usually initially with a chest tube with or without fibrinolytics. Antibiotics should cover pneumococcus, group A streptococcus and MSSA. The need to routinely add additional anaerobic coverage with clindamycin is controversial. For more details, see the Canadian Paediatric Society practice point on management of complicated pneumonia in the present issue of* Paediatrics & Child Health (22)*; §Features that should lead to empirical coverage for MRSA pneumonia pending investigations: Child has severe pneumonia and MRSA accounts for more than 5% of all* S aureus *in the community; child is colonized with MRSA and has severe pneumonia; or child has rapidly progressive disease or pneumatoceles on the chest x-ray, or child has features of septic shock or purpura fulminans. IM Intramuscularly; IV Intravenously; PO Orally*

testing of nasopharyngeal secretions because this will also assist in cohorting patients (15,16).

Bloodwork

Typical bacterial pneumonias usually show higher peripheral white blood cell counts than atypical bacterial or viral pneumonias. A complete blood count with differential testing and blood cultures are indicated for children who are hospitalized or worsening (9,17).

GUIDELINES FOR REFERRAL TO HOSPITAL OR HOSPITAL ADMISSION

Most children can be managed as outpatients. Specific criteria for admission are not available for children. Hospitalization is generally indicated if the child is unable to eat or drink, has an inability to comply with oral therapy, has a concerning social situation, dehydration, hypotension, sepsis, oxygen saturations of lower than 92%, vomiting, tachypnea (Table 1), chest retractions, or any evidence of an empyema or lung abscess (14). There should be a low threshold for admitting children younger than six months of age because it can be difficult for caregivers to recognize deterioration.

MANAGEMENT

If the clinical picture and chest radiograph (CXR) are compatible with bacterial pneumonia, provide supportive care and choose empirical antimicrobials as shown in Table 2, following all steps in the algorithm. This algorithm places less emphasis on macrolides than previous recommendations did because there is increasing evidence that pneumonia due to *M pneumoniae* often resolves without therapy (18).

Suggested doses of antibiotics are listed in Table 3. In all situations, if a bacterium is detected in blood or pleural fluid, antimicrobial therapy should be modified to the narrowest spectrum agent based on susceptibility results.

In Canada, it is still standard to treat uncomplicated pneumonia for seven to 10 days (five days with azithromycin) (19). Pneumonia complicated by empyema or abscess formation requires a longer duration of therapy as determined by the clinical course. Oral step-down therapy is usually appropriate when patients are improved and afebrile.

If a virus is detected in a nasopharyngeal sample and/or CXR is most compatible with viral pneumonia, manage with supportive care (oxygen and rehydration if required) without antibiotics. Consider antivirals if influenza is suspected or proven, and the child has risk factors for severe disease (20) or requires admission, especially if symptoms have been present for less than 48 h.

PENICILLIN ALLERGY

If the previous suspected allergic reaction included an urticarial rash, hypotension or bronchospasm, the reaction may have been immunoglobulin E (IgE) mediated and all beta lactams should be avoided. For children with nonsevere pneumonia who are treated as outpatients, clarithromycin and azithromycin are reasonable choices, while keeping in mind that pneumococcal resistance to antimicrobials is increasingly common. For more severe pneumonias with suspected IgE-mediated penicillin allergy, options should be discussed with a paediatric infectious diseases physician. If the previous suspected allergic reaction did not appear to be IgE mediated, cephalosporins can be used. Cefuroxime axetil can be used in place of amoxicillin, while recognizing that pneumococcal coverage is inferior with these drugs.

EXPECTED CLINICAL COURSE AND FOLLOW-UP FOR UNCOMPLICATED PNEUMONIA

Clinical improvement (improved appetite, decreasing fever, resolution of tachypnea and decreasing oxygen requirements) should be evident within 48 h with bacterial pneumonia; however, improvement often takes longer with viral pneumonia. If the patient does not improve within the expected time frame, repeat the CXR to search for evidence of a complication (ie, empyema or abscess). Foreign body aspiration, reactive airways disease with atelectasis, congenital pulmonary anomaly, tuberculosis or unrecognized immunodeficiency with an opportunistic infection are also possible (Table 2).

Because radiographic resolution can take up to four to six weeks, repeat radiographs are not indicated for children with clinical improvement (21).

TABLE 3
Doses of antimicrobials for suspected or proven bacterial pneumonia

Antibiotic	Route	Regimen
Amoxicillin	PO	75–100 mg/kg/day divided tid*
		Maximum 1 g tid
Amoxicillin-clavulanate	PO	75–100 mg/kg/day of amoxicillin component divided tid†
		Maximum 500 mg tid
Ampicillin	IV	200 mg/kg/day divided q6h
		Maximum 2 g q6h
Azithromycin	IV/PO	10 mg/kg day 1; 5 mg/kg days 2–5
		Maximum 500 mg day 1; 250 mg days 2–5
Cefprozil	PO	30 mg/kg/day divided bid
		Maximum 500 mg bid
Cefotaxime	IV	200 mg/kg/day divided q6h
		Maximum 1500 mg to 2 g q6h
Ceftriaxone	IV	75–100 mg/kg/day divided q12h or q24h
		Maximum 2 g daily
Cefuroxime axetil	PO	30 mg/kg/day divided tid
		Maximum 500 mg tid
Cefuroxime	IV	150 mg/kg/day divided q8h
		Maximum 1.5 g q8h
Clarithromycin	PO	15 mg/kg/day divided bid
		Maximum 500 mg bid
Clindamycin	PO	30–40 mg/kg/day divided tid
		Maximum 450 mg tid
Clindamycin	IV	40 mg/kg/day divided q8h
		Maximum 600 mg q8h
Linezolid	IV/PO	<40 kg: 30 mg/kg/day divided tid
		12 years of age or older 600 mg bid
Vancomycin	IV	40 mg/kg/day divided qid‡
		Maximum 500 mg qid‡

**Although twice daily (bid) dosing is adequate for otitis media, three times daily (tid) dosing is recommended for pneumonia; †Alternatively, one could supplement 50 mg/kg/day of amoxicillin-clavulanate with 25 mg/kg/day to 50 mg/kg/day of amoxicillin to reduce the risk of diarrhea with use of amoxicillin-clavulanate alone. To learn how to do this, go to www.cps.ca/english/statements/ID/ID09-01.htm#TABLE4; ‡Higher doses may be indicated for highly resistant strains of methicillin-resistant* Staphylococcus aureus. *IV Intravenously; PO Orally; q6h Every 6 h; q8h Every 8 h; q12h Every 12 h; q24h Every 24 h; qid Four times daily*

ACKNOWLEDGEMENT: The authors acknowledge Dr Thomas Kovesi, Paediatric Respirologist, Children's Hospital of Eastern Ontario (Ottawa, Ontario), for his thoughtful review of the physical examination portion of the document. This practice point was also reviewed by the Canadian Paediatric Society's Community Paediatrics and Acute Care committees.

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