Pediatric EM

Variations in the management of pneumonia in pediatric emergency departments: compliance with the guidelines

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ABSTRACT

Objective: We sought to assess compliance with evidence-based guidelines for the management of pediatric pneumonia, including the variations in tests ordered and antimicrobials prescribed. Our primary hypothesis was that compliance with the treatment recommendations from the most current guidelines would be low for antimicrobial prescriptions.

Methods: We conducted a chart review at the Children's Hospital in London, Ont., to assess variation in the management of pediatric pneumonia. All patients aged 3 months to 18 years seen at the pediatric emergency department between Apr. 1, 2006, and Mar. 31, 2007, with a diagnosis of pneumonia were eligible for inclusion in the study.

Results: Compliance with management guidelines was 59.7% (95% confidence interval [CI] 53%–66%, *n* = 211) in children 5–18 years old and 83.0% (95% CI 80%–86%, *n* = 605) in children 3 months to 5 years old. Significant variation existed in the choice of antimicrobial agent for children with pneumonia, with nonrecommended agents frequently prescribed.

Conclusion: Significant variation existed in the management of pediatric pneumonia, and adherence to guidelines was low for the group of patients aged 5–18 years. Future studies should attempt to provide guidance to distinguish between viral and bacterial etiology to allow judicious use of antimicrobials.

Keywords: pneumonia, child, pediatrics, disease management, physicians' practice patterns

RÉSUMÉ

Objectif : Nous avons cherché à évaluer la conformité aux lignes directrices fondées sur des données probantes pour la prise en charge de la pneumonie chez les enfants, y compris les variations dans les tests et les antimicrobiens prescrits. Notre hypothèse principale était que le respect des recom-mandations thérapeutiques des plus récentes lignes directrices était faible quant aux antimicrobiens prescrits.

Méthodes : Nous avons effectué un examen des dossiers à l'Hôpital pour enfants de London, en Ontario, pour évaluer la variation dans la prise en charge de la pneumonie chez les enfants. Tous les patients âgés de 3 mois à 18 ans vus au service des urgences pédiatriques entre le 1 avril 2006 et le 31 mars 2007 et ayant un diagnostic de pneumonie étaient admissibles à l'étude.

Résultats : Le respect des lignes directrices était de 59,7 % (intervalle de confiance [IC] à 95 %, de 53 à 66 %, *n* = 211) chez les enfants de 5 à 18 ans et de 83,0 % (IC à 95 %, de 80 à 86 %, *n* = 605) chez les enfants de 3 mois à 5 ans. Des varia-tions significatives existaient dans le choix d'un agent antimi-crobien chez les enfants atteints de pneumonie, et des agents non recommandés étaient fréquemment prescrits.

Conclusion : Des variations significatives existent dans la prise en charge de la pneumonie chez les enfants, et le respect des lignes directrices était faible pour le groupe de patients âgés de 5 à 18 ans. Les études futures devraient chercher à donner des conseils quant à la distinction entre les étiologies virales et bactériennes pour permettre une utilisa-tion judicieuse des antimicrobiens.

INTRODUCTION

In North America, the annual incidence of pneumonia varies based on age group. For children younger than 5 years, the incidence is 30–45 per 1000 children; for children aged 5–9 years, the incidence is 16–20 per 1000 children; for older children and adolescents, the incidence is also 16–20 per 1000 children.[1-4] Pneumonia can have devastating consequences. For example, in

developing countries, sources estimate that pneumonia causes 2 million childhood deaths annually.[5] The difficulty of identifying the causative agents contributes to the challenge of managing the treatment of pneumonia. Several research studies have shown that the causative agent could not be identified in approximately half of cases.[6–20] As determination of etiology is difficult, empirical therapy is a common treatment course.

Canadian guidelines for the treatment of pediatric pneumonia approach the problem from an age-based, etiologic perspective (Table 1).[21] The consensus group suggests therapy based on age group because of the association of age with particular causative agents. The guidelines favour antibiotics with the narrowest spectral range as well as ease of compliance. In terms of investigations, the guidelines make recommendations based on consensus and the availability of tests, because no gold standards exist for the determination of causative agents. Useful diagnostic tests include chest radiography, complete and differential blood counts, blood cultures, Gram staining and sputum culture, serologic testing for *Mycoplasma pneumoniae*, culture and antigen detection of viruses, a serologic test for viruses and a tuberculin skin test. Conversely, throat cultures and antigen detection of bacteria are not currently recommended. The extent to which these guidelines are followed and the outcome consequence of adherence to these guidelines for children with pneumonia is largely unknown. Kozyrskyj and coworkers[22] attempted to assess compliance with the above guidelines; however, they used an overly stringent interpretation of the guidelines.

Since the publication of these guidelines, trends that might change treatment recommendations include the use of *Haemophilus influenzae* type b vaccine, pneumococcal conjugate vaccine and influenza vaccine. *Haemophilus influenzae* type b vaccination was considered in the treatment guidelines and did not alter recommendations as the vaccine did not confer immunity against nontypeable *Haemophilus influenzae*. Influenza immunizations also have a small impact, as respiratory viruses are still found in 15% of cases.[21] Further, although the introduction of pneumococcal conjugate vaccine likely decreased the frequency of pneumonia due to *Streptococcus pneumonia*, this organism is still an important cause of pneumonia in children.[23,24]

Management of treatment using best evidence and guidelines will facilitate the delivery of high-quality health care and may be both efficient and cost-effective. Awareness of current diagnostic and management behaviour will assist in planning the modification of behaviour to produce the highest quality of care at the lowest possible cost. Judicious use of antibiotics will also reduce the prevalence of pathogens with antimicrobial resistance.[25–27] In pursuit of this goal, we assessed variation in investigations, management and compliance with guidelines in the treatment of pneumonia in children admitted to the emergency department (ED) at the Children's Hospital in London, Ont. Our primary hypothesis was that compliance with treatment guidelines would be low for antimicrobial prescriptions. Our secondary hypothesis was that compliance with investigations guidelines would be high.

METHODS

Patient charts from the Children's Hospital were reviewed. The hospital is a publicly funded tertiary centre affiliated with the University of Western Ontario and uses a combination of electronic and paper-based medical records. The electronic system records tests that are ordered and the test results, and medical notes and prescription orders are stored in the paper record.

The charts of patients aged 3 months to 18 years seen at the pediatric ED between Apr. 1, 2006, and Mar. 31, 2007, with a diagnosis of pneumonia (codes 480–487, 495.9, 507 from the clinical modification of the International Classification of Disease, 9th revision [ICD-9-CM]) were considered eligible for inclusion in the study. Ethics approval was obtained from

Table 1. Summary of the Canadian guidelines for treatment of pediatric pneumonia*

Patient age group	Patient setting, recommendation		
	Outpatients	Patients in hospital	Patients in the intensive care unit
3 mo to 5 yr	Amoxicillin or erythromycin or clarithromycin	Cefuroxime or ampicillin	Cefuroxime plus (clarithromycin or erythromycin)
5–18 yr	Erythromycin or clarithromycin	Erythromycin or clarithromycin (with or without cefuroxime) or ampicillin	Cefuroxime plus (clarithromycin or erythromycin)

*Adapted from Jadavji et al.[21]

the institutional review board at the University of Western Ontario.

The patient's age group (3 mo to 5 yr or 5–18 yr), investigations, antibiotic treatment and route of administration were abstracted from the chart onto a data collection sheet by a reviewer who was unaware of the study's hypothesis. Each investigation was counted once, even if a patient received the same test multiple times. Admission to hospital and recent doctor visits were also recorded. The number of patients with a positive laboratory culture test was noted.

Management

Treatment was considered compliant with management guidelines if the following criteria were met:
- outpatients 3 months to 5 years old were treated with amoxicillin, erythromycin or clarithromycin
- inpatients 3 months to 5 years old were treated with at least cefuroxime or ampicillin
- outpatients 5–18 years old were treated with erythromycin or clarithromycin
- inpatients 5–18 years old were treated with at least erythromycin, clarithromycin or ampicillin

In a subgroup analysis, antimicrobials from the same class were considered suitable substitutes. For example, azithromycin was considered equivalent to erythromycin and clarithromycin, cefprozil was considered a sufficient substitute for cefuroxime, and Clavulin was a sufficient substitute for amoxicillin.

Statistical analysis was completed using SPSS, version 15.0. Continuous variables were reported as means with standard deviation. Categorical variables were described as percentages with 95% confidence intervals. The χ^2 test or Fisher exact test was used to compare proportions between groups. A 2-tailed probability of $p < 0.05$ was used to establish statistical significance.

RESULTS

Chart review

A total of 816 children were seen in the pediatric ED for pneumonia between Apr. 1, 2006, and Mar. 31, 2007. Of these, 605 patients were aged 3 months to 5 years and 211 patients were aged 5–18 years. In the younger age group, 71 patients (11.7%) were admitted to hospital, and 30 children (14.2%) in the older age group were admitted.

Investigations

The investigations ordered are shown in Table 2. The vast majority of these tests would be considered useful by the guidelines criteria.[21] Chest radiography was performed during almost all patient visits, with every 1 in 5 patients also undergoing complete and differential blood counts. The most common culture test ordered was a blood culture. Viral and throat cultures were used to a lesser extent. In the younger age group, 12.1% (15/124) of patients who had cultures ordered yielded positive results compared with 7.3% (4/55) among patients aged 5–18 years. Most of the positive cultures (10/19) were for respiratory syncytial virus.

Compliance with treatment recommendations

Compliance with management guidelines was 59.7% (126/211) in children 5–18 years old and 83.0% (502/605) in children 3 months to 5 years old ($p < 0.001$) (Table 3).[21] Almost all outpatients received antibiotics

Table 2. Investigations ordered in 816 children seen in the pediatric emergency department for pneumonia

Investigation	Age group, no. (%)	
	3 mo to 5 yr, $n = 605$*	5–18 yr, $n = 211$*
Chest radiograph†	590 (97.5)	204 (96.7)
Complete and differential blood counts†	105 (17.4)	49 (23.2)
Blood culture†	84 (13.9)	36 (17.1)
Viral culture†	24 (4.0)	10 (4.7)
Throat culture†	12 (2.0)	9 (4.3)
Other†‡	13 (2.1)	4 (2.0)
Positive culture in patients who had cultures ordered	15/124 (12.1)	4/55 (7.3)

*Unless otherwise stated.
†$p > 0.05$ for a difference in test use between age groups.
‡Other tests include polymerase chain reaction for pertussis, fluid culture, serology and fungal/yeast culture.

Table 3. Compliance with management guidelines in the treatment of pneumonia in 816 children

Age group	No. (%) [95% confidence interval]	
	Compliance	Adjusted compliance*
3 mo to 5 yr, $n = 605$	502 (83.0) [80%–86%]	599 (99.0) [98%–99%]
5–18 yr, $n = 211$	126 (59.7) [53%–66%]	144 (68.2) [62%–74%]

*Calculations based on a reinterpretation of the guidelines that equated antimicrobial agents from the same drug class.

orally, and almost all patients admitted to hospital received antibiotics intravenously. If the interpretation of the guidelines was expanded to accept antimicrobials from the same drug class, the differences between age groups were even more pronounced. In this subgroup analysis, compliance with guidelines was 99.0% (599/605) in the care of children 3 months to 5 years old, and it was 68.2% (144/211) in the care of children 5–18 years old (Table 3).

Significant variation existed in the choice of antimicrobial agent for children with pneumonia (Table 4). Other than the recommended agents, children in the age group 5–18 years also received amoxicillin (8.5% of visits), azithromycin (8.5% of visits), Clavulin (5.7% of visits), cefprozil (4.7% of visits) and clindamycin (1.9% of visits). Other than the recommended agents, children in the age group 3 months to 5 years also received cefprozil (6.9% of visits), Clavulin (4.5% of visits), azithromycin (3.5% of visits), cefotaxime (1.0% of visits) and ceftriaxone (1.0% of visits).

DISCUSSION

Despite the existence of accepted guidelines, we found considerable variation in the management of pediatric pneumonia by physicians in this Canadian pediatric ED. Although the guidelines were published in 1997, they remain the most current guidelines for the management of pediatric pneumonia. For children 5–18 years old, physician compliance with management guidelines was

59.7%, and in younger children it was 83.0%.[21] In the subgroup analysis using drug classes instead of specific agents, the compliance with guidelines was 99.0% in the younger children and 68.2% in the older group of children. Almost all outpatients received antibiotics orally, and almost all admitted patients received antibiotics intravenously. In terms of variation from guidelines, this was primarily related to the fact that a variety of non-recommended agents were prescribed. Children in the age group 5–18 years frequently received amoxicillin, azithromycin, cefprozil, Clavulin and clindamycin. Younger children commonly received azithromycin, cefotaxime, cefprozil, ceftriaxone and Clavulin.

The significant majority of investigations ordered were consistent with guideline recommendations.[21] Chest radiography was used for almost all patient visits, as radiography is the gold standard for the diagnosis of pneumonia; however, a "clinical" diagnosis (e.g., no chest radiograph) of pneumonia still occurred in this academic centre.[28] Other commonly ordered tests were complete and differential blood counts and blood culture. Viral and throat cultures were used to a lesser extent. Only the use of throat cultures would be considered noncompliant with the guidelines.[21] Notably, however, the extent to which these investigations changed management was limited. For example, cultures yielded positive results in 7.3% and 12.1% of patients in the older and younger age groups, respectively, mostly for viral cultures. However, this did not change the management, as 98% of all patients received antimicrobial agents. Possible explanations include the delays in obtaining viral cultures or the clinicians' suspicion of mixed bacterial and viral infections.[14]

Interestingly, physicians were much more compliant with the guidelines for younger compared with older patients. The reasons for this are not clear. Known barriers to implementation of guidelines include parents and physicians having issues with the efficiency of recommended therapies, fear of legal action,[29] perceived lack of flexibility of guidelines and lack of agreement with the guidelines.[30] Given the considerable experience with the agents recommended in young children, it is possible that the guidelines for younger children inspired more confidence than those for older children.

Our findings likely represent an overestimate of guideline adherence, as we did not consider dosing or treatment durations. In addition, the physicians involved in care were all board-certified pediatric emergency specialists at one academic centre, and, thus, adherence to guidelines might not be representative of other centres

Table 4. Choice of antimicrobial therapy in the treatment of pneumonia in 816 children

Antimicrobial agent or route*	Age group, no. (%)	
	3 mo to 5 yr, n = 605	5–18 yr, n = 211
Amoxicillin	337 (55.7)	18 (8.5)
Clarithromycin	134 (22.0)	126 (60.0)
Cefuroxime	45 (7.4)	26 (12.3)
Cefprozil	42 (6.9)	10 (4.7)
Clavulin	27 (4.5)	12 (5.7)
Azithromycin	21 (3.5)	18 (8.5)
Cefotaxime	6 (1.0)	3 (1.4)
Ceftriaxone	6 (1.0)	0 (0.0)
Clindamycin	2 (0.3)	4 (1.9)
Other agents†	10 (1.6)	12 (5.7)
Oral route	593 (98.0)	208 (98.6)
Intravenous route	59 (9.8)	29 (13.7)

*Note that some children received more than 1 antimicrobial agent.
†Other agents include ceftazidime, cephalexin, ciprofloxacin, cloxacillin, erythromycin, meropenem, tobramycin and vancomycin.

or other physicians. Kozyrskyj and coworkers[22] also looked at evidence-based prescribing of antibiotics for children. They used a narrow definition of noncompliance (prescription of any drug other than amoxicillin or erythromycin for a child with pneumonia was considered non–evidence based), even though they were also using the same Canadian guidelines. The authors also did not make any distinction based on age groups. These points make their results difficult to interpret.

Limitations

Our study has several limitations. First, we used a retrospective chart review to assess compliance with guidelines; however, the nature of the medical record system at the Children's Hospital eliminated incomplete data. As mentioned, investigations and results were tabulated electronically, and prescription notes were photocopied. Second, we did not exclude patients with comorbidities from our study population, whereas the guidelines attempted to deal with otherwise healthy children;[21] however, many children with pneumonia have comorbidities. Eliminating this subpopulation would reduce the population of patients drastically and limit generalizability. It should be noted that guidelines for children with pneumonia and other health issues do not currently exist. Third, our physician population consisted of pediatric emergency specialists at one centre, which might not be representative of the general physician population or physicians at other centres.

CONCLUSION

This study assessed the variation in management and compliance with guidelines in the treatment of pediatric pneumonia in a Canadian ED. Whereas the vast majority of investigations ordered were consistent with guidelines recommendations, we also found that significant heterogeneity existed in the types of antimicrobials prescribed for pediatric pneumonia. For antimicrobials, compliance with guidelines was much lower for patients 5–18 years old; however, the reasons for this were not clear. Further studies need to examine reasons for this discrepancy and whether adherence to guidelines actually improves clinical outcome. Our findings suggest that clinicians should be aware of the limited utility of many of the tests ordered and be more judicious in antimicrobial use. Future research could attempt to identify better methods at establishing etiology, especially distinguishing between bacterial and viral pneumonia. This latter distinction could markedly reduce the prescription of antibiotics for pneumonia and decrease the prevalence of microbes with antibiotic resistance. Guidelines are needed for the therapy of children with pneumonia with other comorbid conditions. Finally, cost-effectiveness studies of pediatric pneumonia management are needed, particularly exploring the utility and costs of investigations.

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