ORIGINAL ARTICLE

Chest x-ray: an unnecessary resource in the diagnosis of acute bronchiolitis

Ricardo Castillo Galván,[1,2] and Carlos A. Cuello García[2,3]

ABSTRACT

Background. Bronchiolitis is one of the leading controversial pediatric diseases because of its variations in diagnosis and treatment. Use of diagnostic resources beyond the clinical features is usually unnecessary in its classic presentation. The objective of this study was to evaluate the prevalence of significant abnormalities in radiographic findings performed on infants <24 months of age who were hospitalized through the emergency department with the diagnosis of bronchiolitis, as well as to assess whether clinical variables can accurately identify children with abnormal chest x-ray in order to reduce unnecessary radiation exposure.
Methods. From September 2006 to March 2007, infants aged <24 months evaluated and hospitalized through the emergency department of the Hospital San Jose Tec de Monterrey with a diagnosis of bronchiolitis were included in the study. Clinical variables were registered (age, gender, time since onset, oxygen saturation) and laboratory variables as well (leukocytes, lymphocytes, virus identified). Information from the chest x-ray was also obtained.
Results. There were 128 patients included; 70% were aged <12 months. Chest x-ray was performed in 122 patients (95.31%) and respiratory virus studies were done in 119 patients (92.96%). There were 69 patients who were positive (57.99%); respiratory syncytial virus was demonstrated in 62 samples (89.85%) and 15 patients (12.29%) showed abnormal chest x-ray (atelectasis/consolidation). No differences were found between patients with and without chest x-ray abnormalities in clinical and laboratory variables.
Conclusions. Most patients with bronchiolitis had a normal chest x-ray. Our study suggests that x-rays in children with typical bronchiolitis have limited value.

Key words: bronchiolitis, chest x-ray, atelectasis, pulmonary consolidation, respiratory syncytial virus.

INTRODUCTION

Bronchiolitis is the most common lower respiratory tract disease in children <2 years of age and the first cause of hospitalizations in this age group.[1-3] Worldwide, 2-3% of all children <1 year of age are admitted annually with a diagnosis of bronchiolitis.[4]

This clinical entity is produced by a viral infection. It presents at the level of the respiratory epithelium with proliferation of the calyceal cells, resulting in increased mucus production and necrosis and regeneration of the nonciliated epithelial cells. This causes a delay in removing secretions, as well as the presentation of an acute inflammation caused by lymphocytic infiltration associated with mucosal edema. It also presents a cascade phenomenon with the released cytokines and chemokines that amplify the immune response by increasing cell recruitment. This results in the imminent obstruction of bronchioles by edema and cellular debris, causing hyperinflation and increased airway resistance, resulting in wheezing and alterations in ventilation/perfusion. However, bronchoconstriction has not been described during this physiopathological process.[1,5]

Bronchiolitis is recognized as the first episode of wheezing caused by a virally induced lower respiratory tract infection. The major signs and symptoms include cough, tachypnea, crackles, wheezing, intercostal rubbing and/or nasal flaring. The most common etiology is respiratory syncytial virus (RSV) of seasonal occurrence, with the highest incidence between November and March and annual variations associated with the rainy season.[2,6]

1 Brigham and Women's Hospital, Harvard Medical School, Boston, Massachusetts
2 Departamento de Pediatría, Hospital San José Tec de Monterrey, Monterrey, Nuevo León, México
3 Centro de Medicina Basada en Evidencia, Escuela de Medicina, Instituto Tecnológico y de Estudios Superiores de Monterrey, Monterrey, Nuevo León, México

Correspondence: Ricardo Castillo Galván, MD
Newborn Medicine
Brigham and Women's Hospital
Boston, MA
E-mail: rcastillo-galvan@partners.org

Received for publication: 5-3-10
Accepted for publication: 2-21-11

During the first 3 years of life, 90% of children are infected with RSV and 40% develop lower respiratory tract infections.[7] However, RSV does not guarantee immunity to subsequent infection, so an individual may have multiple infections during infancy.[1,8]

Other viruses that have been identified as etiologic agents of bronchiolitis are the three types of parainfluenza virus, human metapneumovirus and, less commonly, adenovirus, influenza virus, rhinovirus, coronavirus and human Boca virus (the latter described in 2005).[9]

Several studies have shown significant variation in the diagnosis and treatment of bronchiolitis. In the U.S., Canada, New Zealand and Holland, variations have been shown that correlate with regional, hospital or even individual treatment preferences according to the severity of the illness in each patient. In some countries, the time of hospitalization may be, on average, two times that of other countries, suggesting a lack of consensus among the medical community to improve the practice.[9,10]

McConnochie criteria for diagnosis include the following: 1) age <24 months, 2) history of coryza, 3) acute dyspnea (with or without increased laboral breathing), and 4) being the first episode.

These criteria, interestingly, do not take into account wheezing, which is a cardinal sign. Even within the definition of the disease these criteria do not take into account rales, tachypnea, fever and vomiting, which are present in many cases.[11] Furthermore, in September 2000 the French consensus defined the criteria for bronchiolitis as follows:

1) Patients <2 years of age
2) Rapid onset (48-72 h) of nasopharyngitis (with or without fever)
3) Association with some of the following signs and symptoms: dyspnea with tachypnea, retractions, chest distention (clinical or radiological), difficulty breathing, wheezing and/or predominantly expiratory crackles (although in more severe forms these may be silent on auscultation)
4) That the first episode coincides with the epidemic period of RSV

These criteria are broader and, therefore, more sensitive for detecting the disease.[12] Traditionally, clinicians who make the diagnosis of bronchiolitis are driven by experience and systematically use auxiliary diagnostic resources, such as chest x-ray.[13, 14]

Although chest x-ray is a common practice in many cases, it is unnecessary. It presents variable data, not specific. Among expected data of the physiopathology of the disease such as lung hyperinflation, peribronchial thickening, increased interstitial markings and diffuse infiltrates, it is rare to find atelectasis, isolated pulmonary infiltrates and pulmonary consolidations. Diagnosis is purely clinical and radiological changes have little influence on the initial management of disease.[4,13]

Other laboratory studies such as blood count and analysis of nasal mucus in search of the viral etiologic agent have become popular aids for diagnosis. Blood count provides information on the inflammatory reaction and its influence on cell count. On the other hand, among the respiratory viral panel, immunofluorescence of the following seven viruses is carried out: RSV, adenovirus, influenza A, influenza B, and parainfluenza 1, 2 and 3. The usefulness of this study is only confirmatory because it does not change management decisions if there is a clinical suspicion of viral bronchiolitis.[2]

Currently, treatment has diversified and is often based more on experience than on the strong evidence from clinical trials, use of bronchodilators, racemic epinephrine, antibiotics, inhaled or systemic steroids. Treatment is not always based on recommendations or clinical guidelines or the evidence obtained from systemic reviews such those published of the Cochrane collaboration.[2,14-18]

When patients are admitted with a diagnosis of bronchiolitis, the use of chest x-ray is a recurring practice in our country that raises health care costs and increases exposure to ionizing radiation without altering the course of the disease or its treatment.

Diagnosis of bronchiolitis is based on a very comprehensive clinical assessment that is not recorded in any scoring system or 'score' to determine which patients are at greater risk of complications, in order to justify the use of an imaging study based on its clinical characteristics, some of which have been associated with increased frequency for radiographic changes among which are desaturation and fever.[13] The main objective of this study was to determine the frequency of significant radiographic changes in patients <24 months of age hospitalized with bronchiolitis and to analyze the relationship between clinical and laboratory variables with the occurrence of any significant change in the chest x-ray.

SUBJECTS AND METHODS

We retrospectively analyzed data of patients admitted to the Hospital San Jose Tec de Monterrey with a diagnosis of bronchiolitis from September 1, 2006-March 31, 2007. We included previously healthy patients <24 months of age who were admitted through the emergency department with diagnosis of bronchiolitis. We excluded those patients who had underlying diseases (i.e., gastroesophageal reflux disease, congenital heart disease or conditions associated with chronic lung infection) and those whose medical records did not have the data required for our study. The information obtained was categorized as identification, clinical variables, laboratory and imaging studies and therapeutic regimen. Information was the recorded on a standardized data sheet.

The identification category included hospital record, date of admission, date of birth, age, sex, medical history and data of prematurity. Clinical variables included heart rate (HR, beats/min), respiratory frequency (RF, breaths/min), temperature (fever ≥38°C taken from axillary region or rectally), oxygen saturation (O_2 Sat) and environment (classified as oxygen desaturation when pulse oximetry performed in the emergency department upon arrival was <93%). Also included were data such as respiratory distress: tachypnea (RF greater than the limits for age, with >35 breaths/min for those patients >1 year and >40 breaths/min for those patients <1 year of age),[19] thoracoabdominal dissociation, intercostal retractions, nasal flaring, respiratory noises during breathing, and other clinical data such as wheezing, crackles, and rattling snoring. Other variables were included that could be associated with the disease such as runny nose and vomiting.

In the category of laboratory and imaging studies, it was recorded whether a chest x-ray was performed and its interpretation by the radiologist, scoring as radiographic patterns using the following two options:

1) No significant changes—included were those x-rays interpreted by the radiologist as normal or expected for the disease and these studies were interpreted as without changes, parahilar peribronchial infiltrate and/or air trapping.
2) Abnormal pattern—x-rays that showed atelectasis and or lung consolidation, pleural effusion or pneumothorax were included.

It was also recorded whether respiratory viral panel indicated in the first 24 h of hospitalization was performed via nasal aspiration and analyzed by immunofluorescence. Also obtained were laboratory blood values and differential count. In the category of therapeutic variables, immediate management including use of bronchodilator, use of racemic epinephrine, inhaled steroids, systemic steroids (oral and/or parenteral), use of antibiotics or antiviral therapy were recorded. Once data were obtained, we divided the population into two groups according to presence or absence of radiological abnormalities.

Within the statistical analysis, quantitative variables were expressed as mean ± SD and qualitative variables as proportions. The values of the frequency of anomalies and description of baseline characteristics of all patients included were elaborated.

First, a univariate analysis was performed comparing the two groups using χ^2 test (Fisher) when they were categorical variables or Student t test with normally distributed continuous variables. All tests were two-tailed; p values <0.05 were considered significant. Within the same univariate analysis, individual contingency tables were constructed and odd ratios (ORs) were obtained with their respective 95% confidence interval (95% CI).

Subsequently, multivariate analysis was performed using binary logistic regression variable taking the normal/abnormal variable as the dependent variable and all others as independent variables.

Due to the characteristics of the study it was only considered necessary to maintain the anonymity of the data without approval of the ethics committee of our institution. Descriptive statistics were evaluated using the programs Microsoft Excel and Numbers, both MAC OS X 10.4 platform and the Statistical Package for Social Sciences for Windows (v.13.0) (SPSS, Chicago, IL).

RESULTS

From September 1, 2006-March 31, 2007, 172 patients were admitted with a diagnosis of bronchiolitis. Of these, 44 patients were excluded (28 were not admitted through the emergency department, nine patients due to incomplete information in the clinical files, four patients for being over the age indicated for the study, two patients due to previous heart disease and one patient for suspected cystic fibrosis). Considered for the study were 128 children <24

months old who were admitted through the emergency department (Figure 1).

The value of the mean ± SD age was 7.39 ± 5.8 months with an interquartile range of 3-11 months. Fifty patients (39.06%) were female. Chest x-rays were performed on 122 patients (95.31%) and respiratory viral panel on 119 patients (92.96%). Of these patients, 69 were positive (57.99%), predominantly RSV in 62 samples (89.85%) followed in frequency by parainfluenza virus in four patients (8.3%) and adenovirus in three patients (4.34%); 50 samples were negative (42.01%). The average number of days of evolution since arrival at the emergency department was 4.6 ± 3.3 days. Initial O_2 saturation in the group of patients was 95.64 ± 3.47% and 23 patients (17.96%) had O_2 sat <93%. Fever occurred in 62 children (48.43%). Finally, the presence of significant alterations in the chest x-ray occurred in 15 (12.29%) of 122 patients who underwent the study. The rest of the studies resulted in the expected pattern for the disease (Table 1). Univariate analysis found no significant difference when comparing radiographic patterns in both groups (Table 2). Only two variables approached statistical difference: thoracoabdominal dissociation with $p = 0.06$ with unadjusted OR 3.85 (95% CI 1.14-12.9) and positive respiratory viral panel with $p = 0.06$ with OR of 4.01 (95% CI 0.83-19).

When performing binary logistic regression, the model retained the presence of positive respiratory viral panel as a factor associated with an increase in the probability of observing consolidation or atelectasis in the chest x-ray (OR to find a normal x-ray: 0089 [95% CI 0.008-0.94]). It was also demonstrated that the days of evolution prior to admission showed a trend towards statistical significance (OR 1.22 [95% CI 0.99-1.52]).

DISCUSSION

Bronchiolitis continues to lead respiratory illnesses requiring hospitalization among the affected pediatric population seasonally in children <2 years of age. The main etiologic agent continues to be the RSV whose characteristics give it the ability to reinfect, even during the same seasonal period. Its survival skills make this virus highly contagious; therefore, bronchiolitis becomes a disease of high demand for clinical care.

There are still controversies about the diagnosis and appropriate treatment, differences that reflect the variety of clinical care throughout countries, call centers and physicians in particular.[20]

Christakis et al. retrospectively reviewed ~17,400 patients in 30 hospitals in the U.S. and found considerable

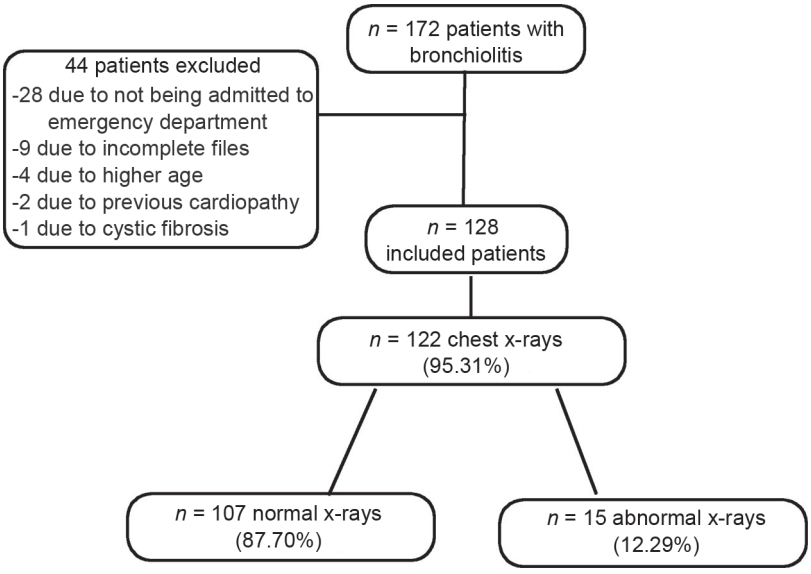

Figure 1. Patient enrollment in the study during the period from September 1, 2006 to March 31, 2007 at the Hospital San José Tec de Monterrey.

Table 1. Radiologic patterns in the study population

Radiologic pattern	*n (%)*
Chest x-ray	122 (95.31)
Chest x-ray (abnormal)	15 (12.29)
Atelectasis	11 (9.01)
Consolidation	4 (3.27)
Chest x-ray (normal)	107 (87.70)
Without data	40 (32.78)
Air trapping	10 (8.19)
Parahilar peribronchial infíltrate	57 (47.54)

variation in the management of patients diagnosed with bronchiolitis. They reported that the performance of chest x-ray showed nonspecific alterations specific to the disease and the subsequent use of antibiotics increased.[14]

Similar studies have been performed where radiological and clinical variables in infants with bronchiolitis were compared. García-García et al. analyzed 252 patients in whom they found that desaturation and fever are significantly associated with radiographic changes; however, they conclude that the vast majority of patients with a

Table 2. Dependent variables

Dependent variables	*Abnormal x-ray*	*Normal x-ray*	*p*	*OR*	*95% CI*
Age (months) median ± SD	6.26 ± 5.52	7.49 ± 5.95	0.45	0.96	0.86-1.00
Sex *n* (%)	M: 7 (46.66%) F: 8 (53.33%)	M: 67 (62.61%) F: 40 (37.38%)	0.23	1.91	0.64-5.67
Days previous to admission	4.93 ± 3.21	4.49 ± 3.41	0.6	1.03	0.89-1.2
SAT O_2	95.53 ± 2.74	95.65 ± 3.64	0.9	0.99	0.85-1.14
SAT O_2 <93% *n* (%)	3 (20%)	19 (17.75%)	0.83	1.15	0.29-4.5
Fever (<38°C) (%)	7 (46.66%)	51 (47.66%)	0.94	0.96	0.32-2.8
Respiratory noises *n* (%)	0	9 (8.04%)	0.34	NE	NE
Nasal flaring *n* (%)	1 (6.66%)	16 (14.95%)	0.38	0.4	0.05-3.3
Thoracoabdominal dissociation *n* (%)	11 (73.33%)	51 (47.66%)	0.06	3.85	1.14-12.9
Intercostal rubbing *n* (%)	8 (53.33%)	59 (55.14%)	0.89	0.93	0.31-2.74
Vomiting *n* (%)	3 (20%)	22 (20.56%)	0.96	0.96	0.25-3.72
Rhinorrhea *n* (%)	11 (73.33%)	82 (76.60%)	0.7	0.83	0.24-2.8
Crepitant rales *n* (%)	4 (26.66%)	36 (33.64%)	0.6	0.71	0.21-2.41
Days of illness	3.93 ± 1.38	4.05± 1.80	0.81	0.96	0.69-1.32
Leukocytes >60% *n* (%)	8 (53.33%)	50 (48.07%)	0.72	1.21	0.40-3.58
Lymphocytes >60% *n* (%)	9 (60%)	52 (50%)	0.44	1.52	0.5-4.6
Neutrofils >10,000/mm^3	2 (13.33%)	8 (7.69%)	0.47	1.82	0.35-9.5
Monocytes >6% *n* (%)	8 (53.33%)	52 (50%)	0.83	1.12	0.37-3.31
RVP+ *n* (%)	10/12 (83.3%)	56/101 (55.4%)	0.06	4.01	0.83-19
RSV+ *n* (%)	9/12 (75%)	56/101 (55.4%)	0.09	3.06	0.78-12
Adenovirus *n* (%)	0/12 (0%)	3/101 (3%)	0.54	NE	NE
Parainfluenza *n* (%)	1/12 (8.3%)	3/101 (3%)	0.34	NE	NE
Prematurity *n* (%)	2 (13.33%)	15 (14%)	0.94	0.94	0.19-4.6
Antibiotic therapy *n* (%)	11 (73.33%)	69 (64.48%)	0.49	1.51	0.45-5.08

Rx, chest x-ray; SAT O_2, oxygen saturation; NE, not evaluated; RVP+, positive respiratory viral panel; RSV+, respiratory syncytial virus positive; OR, odds ratio; CI, confidence interval; NE, not evaluated.

classic presentation of bronchiolitis have an x-ray without significant changes.[13]

Schuh et al. conducted a study with a sample of 265 cases with clinical diagnosis of bronchiolitis, of which only two patients showed significant changes (0.75%). They concluded that in patients with typical clinical diagnosis it is not necessary to perform a chest x-ray because the pattern is almost always consistent with the disease (99.25%).[21]

Our study was conducted in the fourth quarter of the season for bronchiolitis when we analyzed the clinical variables and their relationship with radiographic patterns. No association was found between most variables and clinical or laboratory abnormalities found in the chest x-ray, confirming that the presence or absence of these alterations in patients with bronchiolitis predicts no abnormalities on imaging studies.

Chest x-ray, whether or not demonstrating significant changes, does not predict the behavior of the disease or length of hospital stay. Our results indicated that the progression of the disease was not affected by the presence or absence of abnormalities in the radiological study.

Results of Garcia-Garcia et al. on the association between blood oxygen desaturation and fever were not observed in our study.[13] In contrast, variables that remained statistically significant were the presence of positive respiratory viral panel and the days of disease progression as factors that increased the risk to observe an anomaly in the imaging study. These phenomena can be explained as follows: first, based on positive RSV viral etiology, there is probably a direct association between the presence of the virus and the presence of an infiltrate. Second, regarding the number of days with prior symptoms, it seems likely that at a longer period of time there is a possibility of lung consolidation, whether or not it is secondary to bacterial superinfection. Further studies are needed to verify these explanations.

We continue to believe that the data obtained are helpful in showing no association between clinical or imaging variables with the presence of a radiological abnormality. This situation is repeated in other prospective studies with larger sampling numbers.

Chest x-rays showed no significant alterations in most patients in our study, consistent with some previous studies that reported that radiography is of limited value in the classical presentation of the disease. Clinical or laboratory data examined here cannot predict an abnormal pattern in the chest x-ray in patients with bronchiolitis.

In our environment and public health system, chest x-ray is a common practice. Its performance should not be routine and should be done on an individual basis, depending on the clinical course. Limiting the use of this modality can save resources and also limit the exposure of pediatric patients to ionizing radiation.

REFERENCES

1. Coffin SE. Bronchiolitis: in-patient focus. Pediatr Clin North Am 2005;52:1047-1057.
2. American Academy of Pediatrics Guideline. Diagnosis and management of bronchiolitis. Pediatrics 2006;118:1774-1793.
3. Shay DK, Holman RC, Newman RD, Liu LL, Stout JW, Anderson LJ. Bronchiolitis-associated hospitalizations among US children, 1980-1996. JAMA 1999;282:1440-1446.
4. Smyth RL, Openshaw PJ. Bronchiolitis. Lancet 2006;368:312-322.
5. Barr FE, Graham BS. Respiratory syncytial virus infection: clinical features and diagnosis. Available at: http://www.uptodate.com/contents/respiratory-syncytial-virus-infection-clinical-features-and-diagnosis?source=search_result&selectedTitle=1%7E150
6. Cane PA. Molecular epidemiology of respiratory syncytial virus. Rev Med Virol 2001;11:103-116.
7. Hall CB, Walsh EE, Long CE, Schnabel KC. Immunity to and frequency of reinfection with respiratory syncytial virus. J Infect Dis 1991;163:693-698.
8. American Academy of Pediatrics. Respiratory syncytial virus. In: Pickering, LK, ed. Red Book: Report of the Committee on Infectious Diseases. Elk Grove Village, IL: American Academy of Pediatrics; 2006. p. 561.
9. Allander T, Jartti T, Gupta S, Niesters HG, Lehtinen P, Osterback R, et al. Human bocavirus and acute wheezing in children. Clin Infect Dis 2007;44:904-910.
10. Vogel AM, Lennon DR, Harding JE, Pinnock RE, Graham DA, Grimwood K, et al. Variations in bronchiolitis management between five New Zealand hospitals: can we do better? J Paediatr Child Health 2003;39:40-45.
11. Bordley WC, Viswanathan M, King VJ, Sutton SF, Jackman AM, Sterling L, et al. Diagnosis and testing in bronchiolitis: a systematic review. Arch Pediatr Adolesc Med 2004;158:119-126.
12. Bourrillon A, David S, Vanhuxem CL, Dubus JC, Chabrol B. À propos des bronchiolites aigües du nourrisson [Management of acute bronchiolitis in infants]. Arch Pediatr 2004;11:709-711.
13. García-García ML, Calvo-Rey C, Quevedo-Teruel S, Martínez-Pérez M, Sánchez-Ortega F, Martín del Valle F, et al. Radiografía de tórax en la bronquiolitis: ¿es siempre necesaria? An Pediatr (Barc) 2004;61:219-225.
14. Christakis DA, Cowan CA, Garrison MM, Molteni R, Marcuse E, Zerr DM. Variation in inpatient diagnostic testing and management of bronchiolitis. Pediatrics 2005;115:878-884.

15. Dayan PS, Roskind CG, Levine DA, Kuppermann N. Controversies in the management of children with bronchiolitis. Clin Pediatr Emerg Med 2004;5:41-53.
16. Spurling GK, Fonseka K, Doust J, Del Mar C. Antibiotics for bronchiolitis in children. Cochrane Database Syst Rev 2007;1:CD005189.
17. Gadomski AM, Bhasale AL. Bronchodilators for bronchiolitis. Cochrane Database Syst Rev 2006;3:CD 001266.
18. Patel H, Platt R, Lozano JM, Wang EE. Glucocorticoids for acute viral bronchiolitis in infants and young children. Cochrane Database Syst Rev 2004;3:CD004878.
19. Gunn VL, Nechyba C, Johns Hopkins Hospital. Children's Medical and Surgical Center. The Harriet Lane Handbook: A Manual for Pediatric House Officers. St. Louis: Mosby; 2002.
20. Wilson DF, Horn SD, Hendley JO, Smout R, Gassaway J. Effect of practice variation on resource utilization in infants hospitalized for viral lower respiratory illness. Pediatrics 2001;108:851-855.
21. Schuh S, Lalani A, Allen U, Manson D, Babyn P, Stephens D, et al. Evaluation of the utility of radiography in acute bronchiolitis. J Pediatr 2007;150:429-433.