The Added Value of the Lateral Chest Radiograph for Diagnosing Community Acquired Pneumonia in the Pediatric Emergency Department

Michalle Soudack MD[1,3], Semion Plotkin MD[2,3], Aviva Ben-Shlush MD[1], Lisa Raviv-Zilka MD[1,3], Jeffrey M. Jacobson MD[1], Michael Benacon MD[2,3] and Arie Augarten MD[2,3]

Departments of [1]Pediatric Imaging and [2]Pediatric Emergency Medicine, Safra Children's Hospital, Sheba Medical Center, Tel Hashomer, Israel
[3]Sackler Faculty of Medicine, Tel Aviv University, Tel Aviv, Israel

ABSTRACT: **Background:** Opinions differ as to the need of a lateral radiograph for diagnosing community acquired pneumonia in children referred to the emergency department. A lateral radiograph increases the ionizing radiation burden but at the same time may improve specificity and sensitivity in this population.
Objectives: To determine the value of the frontal and lateral chest radiographs compared to frontal view stand-alone images for the management of children with suspected community acquired pneumonia seen in a pediatric emergency department.
Methods: Chest radiographs from 451 children with clinically suspected pneumonia were retrospectively reviewed. Interpretation of frontal views was compared to interpretation of combined frontal and lateral view, the latter being the gold standard.
Results: Findings consistent with bacterial pneumonia were diagnosed in 94 (20.8%) of the frontal stand-alone radiographs and in 109 (24.2%) of the combined frontal and lateral radiographs. The sensitivity, specificity, positive predictive value, and negative predictive value of the frontal radiograph alone were 86.2%, 93.9%, 81.7%, and 95.5%, respectively. False positive and false negative rates were 15% and 21%, respectively, for the frontal view alone. The number of lateral radiographs needed to diagnose one community acquired pneumonia was 29.
Conclusions: The lateral chest radiograph improves the diagnosis of pediatric community acquired pneumonia to a certain degree and may prevent overtreatment with antibiotics.

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KEY WORDS: chest radiograph, lateral view, community acquired pneumonia (CAP), pediatrics, emergency department

Chest radiograph is the current standard of care for the diagnostic evaluation of children with suspected pneumonia. The Infectious Diseases Society of America (IDSA) strongly recommends both frontal and lateral radiographs in all patients hospitalized for management of community acquired pneumonia (CAP), and a recent review reiterated and stressed the need for both fontal and lateral views for infants and children with lower respiratory tract symptoms [1,2].

The lateral chest radiograph assists in the localization and characterization of findings seen on the frontal view. Certain "blind areas," such as the retro-cardiac space, are better visualized with the lateral view. However, despite the IDSA guidelines, opinions differ as to the need for the lateral view, in part due to the extra radiation exposure [2-9].

In this study we aimed to determine the added value of the lateral chest radiograph for children with suspected CAP.

PATIENTS AND METHODS

PATIENTS

This study included chest radiographs of 461 children referred from the pediatric emergency department with suspected CAP. The images were taken between December 2011 and May 2012. Each child had both a frontal and lateral radiograph.

RADIOGRAPH INTERPRETATION

Radiographs were retrospectively reviewed by one of four pediatric radiologists with at least 8 years of experience. Each radiograph was interpreted in two separate sessions at least 4 weeks apart by the same radiologist, once for the frontal stand-alone and once for the combined frontal and lateral radiographs. Interpretation was in accordance with the World Health Organization (WHO) criteria for findings compatible with bacterial pneumonia. Bacterial pattern was defined as an alveolar infiltrate, lobar, partial lobar, or round infiltrate. Viral infection pattern was defined as one or more of the following: peri-hilar infiltrates, peribronchial cuffing, or sub-segmental atelectasis.

The radiologists were asked to classify the chest radiograph findings according to the following code:

1. Normal
2. Bacterial infection pattern

3. Viral infection pattern
4. Other findings or non-diagnostic

Any interpretation including 2, for example 2 and 3 or 2 and 4 were counted as 2 for the statistical analysis.

DATA ANALYSIS

Combined frontal and lateral radiographs were considered the gold standard. Sensitivity, specificity, positive predictive value, and negative predictive value of the frontal radiograph alone for diagnosing CAP were calculated accordingly. The number of lateral radiographs required to diagnose one CAP (number needed to treat [NNT]) was calculated based on the absolute risk reduction.

The institutional review board approved the retrospective interpretation of the images.

Table 1. Two-by-two contingency table showing results of frontal view alone for diagnosing CAP with frontal and lateral views, the gold standard

		Frontal + lateral	
		109 (CAP positive)	**342 (CAP negative)**
Frontal alone	CAP positive	94	21
	CAP negative	15	321

CAP = community acquired pneumonia

Figure 1. [A] Acquired pneumonia radiograph of a 1 year 3 month old infant shows a vague opacity on the right, **[B]** Lateral view confirms an opacity consistent with alveolar pneumonia in the right middle lobe

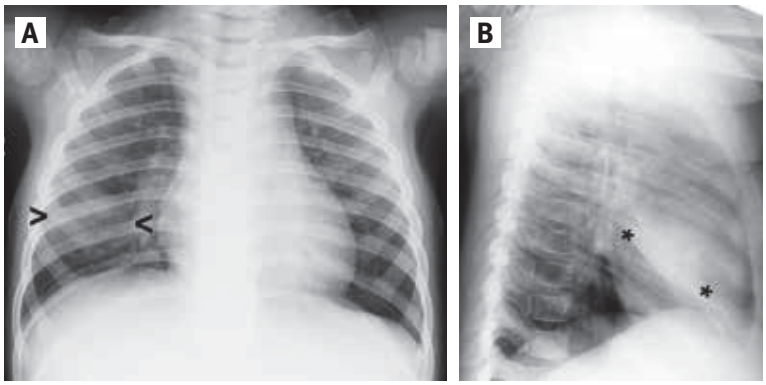
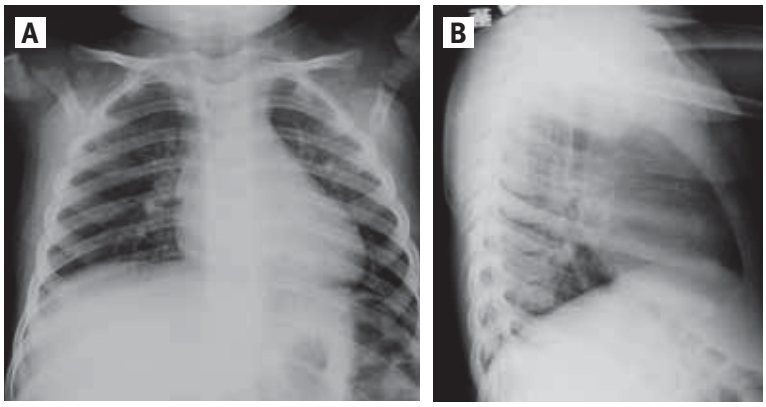


Figure 2. [A] Acquired pneumonia radiograph of 3 year old child with increased retro-cardial density suspicious for alveolar pneumonia, **[B]** Lateral view with no evidence of alveolar opacity



RESULTS

Our study cohort included 451 children aged 1 month to 18 years, mean age 5.1 ± 4.9 years, 192 females and 259 males. Of the 461 children, 10 (2.1%) had lateral radiographs that were deemed non-diagnostic.

Findings consistent with CAP were diagnosed in 109 (24.2%) of the combined frontal and lateral radiographs and in 94 (20.8%) of the frontal stand-alone radiographs. There were 15 false negative and 21 false positive occurrences [Table 1, Figure 1, and Figure 2]. The NNT was 29. This result means that for every 29 lateral radiographs obtained, one CAP was diagnosed. The clinical data for the cases missed on the frontal view alone are presented in Table 2.

The sensitivity, specificity, positive predictive value, and negative predictive value were 86.2%, 93.9%, 81.7%, and 95.5%, respectively.

The agreement between the frontal view only and the frontal and lateral view was 72.4% for all findings. The agreement for findings consistent with CAP was 86%.

DISCUSSION

Accurate diagnosis of CAP is crucial since under-diagnosis may lead to increased morbidity, while over-diagnosis involves unnecessary antibiotic treatment with resultant development of antibiotic-resistance bacteria. Our study results imply that the lateral view improves the diagnosis of CAP in children referred to the emergency department. Using the frontal radiograph alone for our patients would have resulted in 15 under-diagnoses and 21 over-diagnoses [Figure 1 and Figure 2].

The fundamental tenet of radiographic technique has always dictated the need for two or more views. The standard chest series includes a frontal and left lateral view, as recommended by both the IDSA and the Pediatric Infectious Disease Society for the management of CAP in children [1]. However, this recommendation has been challenged due to concerns about additional exposure to ionizing radiation, the increased time taken to perform the lateral radiograph, and increased medical expenses. Moreover, repeat exposure due to lack of technician experience has been considered to add to the radiation burden and time [3-5].

Although lateral chest radiographs double the radiation exposure, an additional effective dose (approximately 0.01–0.02 mSv) from a lateral radiograph in an otherwise healthy child may be negligible with modern state-of-the-art equipment.

Table 2. Clinical data for the cases missed on the frontal view alone

Patient	Age (years)	Gender	History			Physical examination		Sat O_2	Laboratory results	
			Fever	Cough	Other	Auscultation	Other		WBC	CRP
1	6.1	male	yes	yes		normal		93		
2	1.7	male	yes	yes		normal		98	normal	normal
3	9.4	male	yes	yes	convulsion	normal		99	normal	normal
4	15.9	male	yes	yes	chest pain	normal		99	↓	↑
5	1.1	male	yes	no	otalgia	normal		N/A	N/A	N/A
6	5.6	male	no	yes	dyspnea	crackles		87	N/A	N/A
7	2.3	male	yes	no		normal	hepatosplenomegaly	98	N/A	N/A
8	1.7	female	yes	yes	back pain, vomiting	↓ air entry		98	↓	↑
9	11.4	male	no	yes	chest pain, vomiting	heart murmur		N/A	normal count, left shift	normal
10	0.3	female	yes	yes	dyspnea	normal		94	↑	↑
11	0.4	male	yes	yes	dyspnea	wheezing		98	normal	normal
12	1.8	male	yes	yes		crackles		97	N/A	N/A
13	6.0	male	yes	no	chest pain, dyspnea	crackles, wheezing		98	↑	↑
14	6.8	Female	yes	yes	abdominal pain	↓ air entry		93	normal	↑
15	3.1	female	yes	yes	abdominal pain, dyspnea	crackles, wheezing		100	normal	normal

WBC = white blood cell count, CRP = C-reactive protein, N/A = not applicable

As for increased medical expenses, under and over diagnosing CAP also increases costs. To the best of our knowledge, a comprehensive calculation of these expenses compared to the added cost of a lateral chest radiograph has not been reported.

Repeat exposures has also been considered to add to the radiation burden and time [10]. This result is probably due to lack of skilled radiographers experienced with children; that is, staff who can effectively perform lateral radiographs for children.

Our false negative rate (3.3%) and NNT (29) were comparable with other reports assessing the value of the frontal radiograph for diagnosing pneumonia in children, 3–20% and 22–53, respectively [3,5,8,11].

Interpreting pediatric chest radiographs is not wholly objective, as evident by our overall agreement of just 72.4%, and depends on the radiologist's education and experience. This fact may explain the differences in false negative and NNT rates between studies.

In addition to diagnosing CAP, the lateral radiograph can assist in other situations. For example, the overlapping appearance of sub-segmental atelectasis and small alveolar opacities may be elucidated with a lateral radiograph. It is also helpful to confirm cardiomegaly and is more accurate than the frontal view in diagnosing hyperinflation. Round pneumonias often assume a non-round configuration on a lateral chest radiograph, thereby ruling out tumor or cyst, and in the proper clinical scenario may obviate the need for a follow-up film. Pleural fluid initially accumulates in the posterior costophrenic recesses, so on upright radiographs small amounts will be evident on the lateral view only. Subtle perihilar infiltrates such as in bronchiolitis and congestion may be more obvious in the lateral view. Other findings, not necessarily related to CAP but causing respiratory symptoms such as pneumomediastinum, may be refined or even diagnosed de novo with the lateral view.

Recent publications suggest alternatives to the plain radiograph for diagnosing pneumonia, such as magnetic resonance imaging, ultrasound, and iterative reconstruction computed tomography [12-16]. Until these techniques become everyday practice, it is our opinion that the management of children with suspected community acquired pneumonia should include both frontal and lateral radiographs as they not only improve diagnosis but also may prevent overtreatment with antibiotics.

Correspondence

Dr. A. Augarten

Dept. of Pediatric Emergency Medicine, Sheba Medical Center, Tel Hashomer 5265601, Israel

Phone: (972-3) 530-3054, **Fax:** (972-3) 530-5939

email: augarten@post.tau.ac.il

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Capsule

Origin and differentiation of human memory CD8 T cells after vaccination

The differentiation of human memory CD8 T cells is not well understood. **Akondy** et al. addressed this issue using the live yellow fever virus (YFV) vaccine, which induces long-term immunity in humans. The authors used in vivo deuterium labeling to mark CD8 T cells that proliferated in response to the virus and then assessed cellular turnover and longevity by quantifying deuterium dilution kinetics in YFV-specific CD8 T cells using mass spectrometry. This longitudinal analysis showed that the memory pool originates from CD8 T cells that divided extensively during the first 2 weeks after infection and is maintained by quiescent cells that divide less than once every year (doubling time of over 450 days). Although these long-lived YFV-specific memory CD8 T cells did not express effector molecules, their epigenetic landscape resembled that of effector CD8 T cells. This open chromatin profile at effector genes was maintained in memory CD8 T cells isolated even a decade after vaccination, indicating that these cells retain an epigenetic fingerprint of their effector history and remain poised to respond rapidly upon re-exposure to the pathogen.

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Eitan Israeli

Capsule

Targeting the T cell receptor β-chain constant region for immunotherapy of T cell malignancies

Mature T cell cancers are typically aggressive, treatment resistant, and associated with poor prognosis. Clinical application of immunotherapeutic approaches has been limited by a lack of target antigens that discriminate malignant from healthy (normal) T cells. Unlike B cell depletion, pan–T cell aplasia is prohibitively toxic. **Maciocia** and colleagues reported a new targeting strategy based on the mutually exclusive expression of T-cell receptor β-chain constant domains 1 and 2 (TRBC1 and TRBC2). The authors identified an antibody with unique TRBC1 specificity and used it to demonstrate that normal and virus-specific T cell populations contain both TRBC1+ and TRBC2+ compartments, whereas malignancies are restricted to only one. As proof of concept for anti-TRBC immunotherapy, the authors developed anti-TRBC1 chimeric antigen receptor (CAR) T cells, which recognized and killed normal and malignant TRBC1+, but not TRBC2+, T cells in vitro and in a disseminated mouse model of leukemia. Unlike nonselective approaches targeting the entire T cell population, TRBC-targeted immunotherapy could eradicate a T-cell malignancy while preserving sufficient normal T cells to maintain cellular immunity.

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Eitan Israeli

"As societies grow decadent, the language grows decadent, too. Words are used to disguise, not to illuminate, action: you liberate a city by destroying it. Words are to confuse, so that at election time people will solemnly vote against their own interests"

Gore Vidal, (1925–2012), (born Eugene Louis Vidal) American writer and public intellectual known for his patrician manner, epigrammatic wit, and polished style of writing