ERJ Express. Published on July 12, 2006 as doi: 10.1183/09031936.06.00008306

CXR and pneumonia in primary care: diagnostic yield & consequences for patient management

A.M. Speets*, A.W. Hoes[#], Y. van der Graaf[#], S. Kalmijn[#], A.P.E. Sachs[#] and W.P.Th.M. Mali*

Author Affiliations

*Department of Radiology, [#]Julius Centre for Health Sciences and Primary Care, University Medical Centre Utrecht, Utrecht, The Netherlands.

Corresponce

A.M. Speets

Department of Radiology (E01.335)

University Medical Centre Utrecht

P.O. Box 85500

3508 GA Utrecht, The Netherlands

Tel. +31 30 2509007

Fax. +31 30 2581098

E-mail. aspeets@umcutrecht.nl

Running head

Chest radiography & pneumonia in primary care

Abstract

This prospective cohort study assessed the diagnostic yield of chest radiography (CXR) in primary care patients suspected of pneumonia.

In total, 192 patients with a clinical suspicion of pneumonia aged ≥ 18 years were referred by their general practitioner (GP) for CXR to one of the three participating hospitals in The Netherlands. All GPs were asked to fill in a standardized form before and after CXR.

Pneumonia was diagnosed by GPs in 35 patients (18%), of whom 27 patients (14%) had a positive CXR, and 8 patients (4%) a negative CXR, however with an assumed high probability of pneumonia by the GP. CXR clearly influenced the diagnosis of pneumonia by the GP in 53% of the patients: CXR ruled out pneumonia in 47%, and the probability of pneumonia substantially increased in 6% of the patients. Patient management changed after CXR in 69% of the patients, mainly caused by a reduction in medication prescription (from 43% to 17%); and more frequent reassurance of the patient (from 8% to 35%).

Pneumonia was frequently over diagnosed clinically by GPs. CXR is a valuable diagnostic tool to substantially reduce the number of patients misdiagnosed, and particularly important for the exclusion of pneumonia in general practice.

Keywords: Chest radiography, general practice, patient care management, pneumonia

Introduction

Primary care physicians usually rely on patient history, and signs and symptoms to diagnose or exclude pneumonia [1]. However, most signs and symptoms traditionally associated with pneumonia (e.g. fever and coughing) are not predictive of pneumonia in general practice [2-4]. Chest radiography (CXR) is the most frequently performed diagnostic investigation requested by general practitioners (GPs) in Europe: in 22% of patients with a suspected lower respiratory tract infection CXR is requested [5]. CXR is considered the gold standard for pneumonia diagnosis. CXR can diagnose pneumonia in case of presence of an infiltrate, and differentiate pneumonia from other conditions that may present with similar symptoms (e.g. acute bronchitis). In addition, the results may suggest specific aetiologies (e.g. lung abscess), identify coexisting conditions (e.g. bronchial obstruction), and evaluate the severity of illness [6-9].

Although CXR is frequently used for diagnosing pneumonia, little is known about the influence of CXR on the probability estimation of pneumonia by GPs, and on change in patient management. Simpson et al. concluded that results of CXR requested by GPs influenced patient management in 48% of 97 patients with radiographic features of acute infection [10]. However, this study was conducted only in patients with radiographic evidence of infection and the patient management was assessed with questionnaires filled in retrospectively by GPs. When assessing the diagnostic yield of CXR, e.g. in terms of patient management, it is important to study the complete cohort of patients suspected of pneumonia, and not only the subgroup of patients with a radiographic diagnosis of pneumonia.

The objective of this prospective cohort study was to assess the effect of CXR on the probability estimation of pneumonia by GPs, the influence of CXR on patient management and consequences of CXR according to the patient. The study population consisted of primary care patients with a clinical suspicion of pneumonia referred for CXR by GPs.

Methods

Study subjects

This study is part of a large prospective cohort study conducted from April 2003 to December 2004 with the help of 78 GPs participating in the catchment area of one of three general hospitals located in three main cities in The Netherlands (Jeroen Bosch Hospital in 's-Hertogenbosch; Gelre Hospitals in Apeldoorn; 'Onze Lieve Vrouwe Gasthuis' in Amsterdam). In total 870 patients of 18 years and older who were referred for CXR (posteroanterior and lateral view) by their GP to one of these hospitals were included in the cohort study. The study was approved by the medical ethics review board.

The GPs could fill in three probable diagnoses on a standard form before requesting a CXR. In the present study all patients who were referred for CXR with a clinical suspicion of pneumonia as one of these probable diagnoses were included (n=222). Thus, not all patients suspected of pneumonia were referred for CXR and included in the study, only the patients in whom history taking and physical examination provided insufficient information for the GP to distinguish those with from those without pneumonia. Estimated probabilities for 18 patients (8%) were not filled in by the GP before and/or after CXR. These patients were excluded from the study. Their patient characteristics were comparable with the included patients. Patients referred for a follow-up CXR for the treatment evaluation of pneumonia were also excluded (n=12), resulting in a study population of 192 patients. Additionally, all patients with incidental pneumonia detected with CXR were included as a separate patient group (i.e. patients referred for CXR without a clinical suspicion of pneumonia).

Methods

All GPs were asked to fill in a standardized form before requesting a CXR, including information on history, physical examination, indication, probable diagnosis with estimated prior probabilities on a visual analogue scale (range 0-100%), and anticipated patient

management. Abnormalities found during auscultation included crackles, rhonchi and/or bronchial breathing. Percussion was considered abnormal when dull or hyperresonant sounds were detected by the GP. The management options included: referral to a medical specialist; medication prescription; reassurance of the patient; and follow-up by the GP (watchful waiting or additional diagnostic testing). After the GP requests a CXR a patient can be referred for CXR to the general hospital at the same day. In general all CXRs are reported by a radiologist within 24 hours. Any significant abnormalities will be verbally reported to the GP, before the official radiologic report is sent by mail. Therefore, significant abnormalities will normally be received by GPs within one day, and they directly can adjust their patient management plan. When no significant pathology is detected with CXR, it can take up to four days before the GP receives the official radiologic report. After the GP received the report he or she filled in a second questionnaire, again including the probable diagnosis with estimated posterior probabilities, and anticipated patient management plan. We considered a decrease or increase in the estimated probability of pneumonia by the GPs after CXR of ≥ 30% as a substantial change in the probability estimation.

The findings on the CXR were categorized into four groups: (1) pneumonia; (2) other clinically relevant abnormalities; (3) a known abnormality, which was detected previously on CXR; (4) no abnormality. Pneumonia was defined as a consolidation or infiltrate described by the radiologist in the CXR report, often summarized as pneumonia in the conclusion of the radiologist. Six months after the CXR a short questionnaire was sent to all patients (response rate 84%), in order to evaluate their current complaints and assess the consequences of CXR according to the patient.

Analysis

The primary outcome measures for our study were the proportion of patients with a clear shift in the probability estimation of pneumonia by the GP (≥ 30% decrease or ≥ 30% increase of

the estimated probability after CXR), and the proportion of patients in whom there was a change in patient management by the GP following CXR. These proportions and corresponding 95% confidence intervals were calculated using the statistical program Confidence Interval Analysis [11].

Results

The mean age of the patients with a clinical suspicion of pneumonia was 56.8±17.6 years, and 55% were male. Fifteen percent of the patients had a prior diagnosis of pneumonia. Cough was the most frequently reported symptom among the patients (66%). Abnormalities during auscultation and percussion were found in respectively 59% and 26% of the patients (Table 1).

The radiology reports of CXR showed pneumonia in 27 patients (14%); other clinically relevant abnormalities in 32 patients (17%); a known abnormality, which was detected previously on CXR in 35 patients (19%) and no abnormality in 98 patients (52%). The group other clinically relevant abnormalities consisted of 1 malignancy, 23 patients with COPD/ asthma/chronic bronchitis, 4 abnormalities that required further investigation, and 4 other abnormalities (e.g. diaphragmatic hernia).

The distributions of the prior and posterior probability of pneumonia are shown in Figure 1 and the number of patients with a low (<30%), moderate (30-70%) or high (>70%) probability of pneumonia according to the GP before and after CXR are shown in the flow diagram in Figure 2. Noticeable were the two large groups referred for CXR with a very low or high prior probability of pneumonia, 64 patients (33%) and 30 patients (16%) respectively. After CXR, pneumonia was diagnosed in 4 of the 64 patients (6%) with a very low prior probability, and in only 15 of the 30 patients (50%) with a very high prior probability of pneumonia. The probability estimation of pneumonia was clearly changed by means of CXR in 53% of the patients (95% CI 46%-59%). The estimated probability of pneumonia decreased with ≥ 30% (range 30-100%) in 89 patients (47%), and increased with ≥ 30% (range 30-80%) in 12 patients (6%) after CXR.

The proportion of patients for whom patient management changed following CXR was 69% (95% CI 62%-75%). Main changes in patient management plans after CXR included: a reduction in the number of patients with a medication prescription from 79 (43%) to 32 (17%) patients; and more frequent reassurance of the patient, from 15 (8%) to 64 (35%) patients

(Table 2). The reduction in medication prescription was caused mainly by a decrease in the prescription of antibiotics from 53 patients (28%) before CXR to 26 patients (14%) after CXR.

Six months after the CXR the current complaints were diminished or disappeared in almost 80% of the patients referred for CXR by GPs with a clinical suspicion of pneumonia. Only 15% of the patients who returned the questionnaire reported that CXR had no value for him or her. CXR resulted in a definite diagnosis or better treatment according to 43% of the patients, and 44% of the patients were reassured after CXR.

Pneumonia was diagnosed with CXR in 27 patients (14%), with a mean age of 53.8±18.8 years, and 44% were male. Abnormalities during auscultation and percussion were found in respectively 74% and 26% of these patients. The GPs referred 7 patients (26%) to a medical specialist, medications were prescribed in 13 patients (48%), patient management was watchful waiting in 6 patients (22%), and an additional CT scan was ordered for 1 patient (4%). Six months after the CXR the current complaints were diminished or disappeared in 72% of the patients, and 8% reported that CXR had no value for him/her.

Additionally, pneumonia was diagnosed by the GP in 8 patients (4%) without a positive CXR, however with an assumed high probability of pneumonia by the GP. The GP suspected pneumonia in 4 patients, viral pneumonia in 2 patients, and mycoplasma pneumonia was shown with additional laboratory investigation in 2 patients. The 4 patients suspected of pneumonia were: 1) 48-years old male with a medical history of COPD, 2 weeks complaints of cough and thoracic pain, without abnormalities during physical examination; 2) 52-years old female who smoked, 1 week complaints of cough, dyspnoea and fever, without abnormalities during physical examination; 3) 62-years old female with a colleague diagnosed with pneumonia, 1.5 week complaints of cough, and crepitations on the left side; 4) 20-years old female with an infiltrate in her medical history (2,5 years ago), some days complaints of cough, thoracic pain and fever, and without abnormalities during physical examination. After CXR 4 of the 8 patients were referred to a medical specialist, and medications were prescribed in 4

patients. Six months after the CXR the current complaints were diminished or disappeared in 71% of the patients, and 14% reported that CXR had no value for him/her.

Small infiltrates or early manifestations of pneumonia were found as an incidental finding with CXR in 5 patients (age range 32-77 years; 3 males) of the total cohort of 870 patients (<1%). Two patients were referred for CXR for the exclusion of a malignancy, 1 patient for the confirmation of COPD, and 2 patients had unclear complaints without any abnormalities during physical examination. After CXR 3 patients were referred to a medical specialist, medications were prescribed in 1 patient, and patient management was watchful waiting and an additional follow-up CXR in 1 patient.

Discussion

CXR clearly influenced the diagnosis of pneumonia by the GP in 56% of the patients referred for CXR with a clinical suspicion of pneumonia: CXR ruled out pneumonia in 50% of the patients, and the probability of the diagnosis pneumonia substantially increased in 6% of the patients. The proportion of patients for whom patient management changed following CXR was 69%, mainly caused by a decrease in the prescription of antibiotics, and more frequent reassurance of the patient.

To our knowledge, this study is the first that assessed the effect of CXR on the probability estimation of pneumonia by GPs. The number of patients in whom the patient management changed (69%) is much higher than the 48% reported in the study of Simpson et al. [10]. This difference could be explained by the study designs: their study was conducted in patients with radiographic evidence of infection and the patient management was assessed with questionnaires filled in retrospectively by GPs, which may have biased the results. Besides, Simpson et al. did not specify whether reassurance of the patient was considered as patient management, and how patient management was influenced by the findings of CXR.

The distributions of the prior and posterior probability of pneumonia in Figure 1 showed that the uncertain area of a diagnosis, around estimated probabilities of 50%, disappeared largely as a consequence of CXR. Noticeable in our study was that almost half of all patients were referred for CXR with a very low or high prior probability of pneumonia, respectively 33% and 16% of the patients. Seventy-five percent of the patients with a very low prior probability of pneumonia had additional differential diagnoses, such as COPD or acute bronchitis, with a higher prior probability according to the GP. After CXR, pneumonia was diagnosed in only 6% of the patients with a very low prior clinical probability of pneumonia, and therefore, CXR was not a useful tool for diagnosing pneumonia in these patients. Pneumonia was diagnosed after CXR in only 50% of the patients with a very high prior probability of pneumonia. This emphasizes the importance of referring patients with a clinical

suspicion of pneumonia for CXR, even when the prior probability of pneumonia is very high according to the GP.

Pneumonia was diagnosed by the GP in 35 patients (18%): 27 (14%) had a positive CXR, and 8 patients (4%) a negative CXR, however with an assumed high probability of pneumonia by the GP. Low percentages of patients diagnosed with pneumonia by a positive CXR were also found in other studies: 15% by Melbye et al. [12], and 7% by Lieberman et al. [13]. It is noticeable that the estimated probabilities in the patient groups diagnosed with pneumonia with a positive and negative CXR were high before CXR, 61% and 72% respectively. However, these percentages were not high enough for the GPs to start treatment or refer patient to a medical specialist without an additional CXR. The current restrictive policy of prescribing antibiotics could encourage the GPs to order CXR in patients suspected of pneumonia even when estimated prior probabilities are high based on medical history, anamnesis and physical examination [9].

The manifestations of pneumonia on CXR may vary considerably, depending upon the degree of inflammation and the stage of the disease process. It is difficult to diagnose mild or early stage pneumonia by CXR [14, 15]. Besides, it is possible to detect pneumonia during physical examination without roentgengraphic evidence [14]. The 8 patients with a high estimated probability of pneumonia, and a negative CXR might have been referred too soon for CXR by their GP; mycoplasma pneumonia was shown with additional laboratory investigation in 2 of these 8 patients.

Interestingly, no clear differences in patient characteristics, including signs and symptoms, were observed in referred patients with or without pneumonia. This indicates that the GPs adequately applied their clinical skills to select those patients for additional imaging in whom history taking and physical examination provided insufficient information to distinguish those with from those without pneumonia.

As expected, pneumonia was found scarcely as incidental finding with CXR. In our study, small infiltrates or early manifestations of pneumonia were found as an incidental finding in less than 1% of the patients of the total cohort of 870 patients.

A limitation of our study is that it was impossible to verify whether or not the GP really would have conducted the anticipated patient management in accordance with the plan made on the standardized form before CXR was performed. This could result in an overestimation of intended referrals to medical specialists.

In conclusion, pneumonia was frequently over diagnosed clinically by the GPs in this study. CXR is a valuable diagnostic tool in primary care patients with a clinical suspicion of pneumonia referred for CXR to substantially reduce the number of patients misdiagnosed. In particular, CXR was important for the exclusion of pneumonia in general practice. CXR was not very useful for diagnosing pneumonia in patients with a low clinical probability of pneumonia.

Acknowledgments

It would not have been possible to conduct this study without the participation of all GPs from the catchment areas of the three hospitals! We wish to thank the radiologists and trial nurses for their help with all the logistics in the three participating hospitals: Matthieu Rutten and Han de Koning working in the Jeroen Bosch Hospital in 's-Hertogenbosch; Jan Willem Gratama and Ireen Brussee from the Gelre Hospitals in Apeldoorn; and Alexander Montauban van Swijndregt and Cecil Kressenhof from the 'Onze Lieve Vrouwe Gasthuis' in Amsterdam. We thank Cees Haaring from the University Medical Centre Utrecht for making the database and his assistance with the data management.

References

1. Metlay JP, Fine MJ. Testing strategies in the initial management of patients with community-acquired pneumonia. *Ann Intern Med.* 2003;138(2):109-118.
2. Hopstaken RM, Muris JW, Knottnerus JA, Kester AD, Rinkens PE, Dinant GJ. Contributions of symptoms, signs, erythrocyte sedimentation rate, and C-reactive protein to a diagnosis of pneumonia in acute lower respiratory tract infection. *Br J Gen Pract.* 2003;53(490):358-364.
3. Metlay JP, Kapoor WN, Fine MJ. Does this patient have community-acquired pneumonia? Diagnosing pneumonia by history and physical examination. *JAMA.* 1997;278(17):1440-1445.
4. Mabie M, Wunderink RG. Use and limitations of clinical and radiologic diagnosis of pneumonia. *Semin Respir Infect.* 2003;18(2):72-79.
5. Woodhead M, Gialdroni Grassi G, Huchon GJ, Leophonte P, Manresa F, Schaberg T. Use of investigations in lower respiratory tract infection in the community: a European survey. *Eur Respir J.* 1996;9(8):1596-1600.
6. Niederman MS, Mandell LA, Anzueto A, et al.; American Thoracic Society. Guidelines for the management of adults with community-acquired pneumonia. Diagnosis, assessment of severity, antimicrobial therapy, and prevention. *Am J Respir Crit Care Med.* 2001;163(7):1730-1754.
7. British Thoracic Society Standards of Care Committee. BTS Guidelines for the Management of Community Acquired Pneumonia in Adults. *Thorax.* 2001;56 Suppl 4:IV1-64.
8. Mandell LA, Marrie TJ, Grossman RF, Chow AW, Hyland RH. Canadian guidelines for the initial management of community-acquired pneumonia: an evidence-based update by the Canadian Infectious Diseases Society and the Canadian Thoracic Society. The Canadian Community-Acquired Pneumonia Working Group. *Clin Infect Dis.* 2000;31(2):383-421.
9. Bartlett JG, Dowell SF, Mandell LA, File Jr TM, Musher DM, Fine MJ. Practice guidelines for the management of community-acquired pneumonia in adults. Infectious Diseases Society of America. *Clin Infect Dis.* 2000;31(2):347-382.
10. Simpson JCG, Hulse P, Taylor PM, Woodhead M. Do radiographic features of acute infection influence management of lower respiratory tract infections in the community? *Eur Respir J.* 1998; 12: 1384-1387.
11. Altman DG, Machin D, Bryant TN, Gardner MJ. Statistics with confidence. 2nd edition. London: BMJ Books, 2000.

12. Melbye H, Straume B, Aasebo U, Brox J. The diagnosis of adult pneumonia in general practice. The diagnostic value of history, physical examination and some blood tests. *Scand J Prim Health Care*. 1988; 6(2):111-117.
13. Lieberman D, Shvartzman P, Korsonsky I, Lieberman D. Diagnosis of ambulatory community-acquired pneumonia. Comparison of clinical assessment versus chest X-ray. *Scand J Prim Health Care*. 2003; 21(1):57-60.
14. Fraser RG, Paré JAP. Pneumonia. Diagnosis of diseases of the chest. 2nd edition. Philadelphia/London/ Toronto: W. B. Saunders Company, 1978.
15. Melbye H. Community pneumonia--more help is needed to diagnose and assess severity. *Br J Gen Pract.* 2002;52(484):886-888.

TABLE 1. Patient characteristics (n=192)

	n (%)
Age (mean ± sd in years)	56.8±17.6
Gender (male)	106 (55)
Prior diagnoses	
Malignancy (various locations n=7; lung n=2)	9 (5)
Pneumonia	28 (15)
COPD/asthma/chronic bronchitis	48 (25)
Recent prescription of antibiotics	45 (23)
History taking	
Smoking	32 (17)
Pain	27 (14)
Haemoptysis	13 (7)
Cough	127 (66)
Dyspnoea	54 (28)
Other symptoms of respiratory infection*	39 (20)
Fever	33 (17)
General malaise	25 (13)
Physical examination	
Abnormalities during auscultation	113 (59)
Abnormalities during percussion	49 (26)

* Abnormal sputum, nasal congestion, throat symptoms, and complaints of a cold

TABLE 2. Patient management plans of general practitioners before and after chest radiography*

BEFORE (n) / **AFTER (n (%))**	Referral medical specialist	Medication prescription	Reassurance	Follow-up by GP†	Total
Referral medical specialist	**10 (24)**	14 (18)	1 (7)	4 (8)	29 (16)
Medication prescription	7 (17)	**19 (24)**	0	6 (12)	32‡ (17)
Reassurance	16 (38)	18 (23)	**10 (67)**	20 (41)	64‡ (35)
Follow-up by GP†	9 (21)	28 (35)	4 (27)	**19 (39)**	60 (32)
Total	42 (23)	79 (43)	15 (8)	49 (26)	185

* Patient management plans for 7 patients (4%) were not filled in by the GP before and/or after chest radiography

† Follow-up by GP: predominantly watchful waiting or additional diagnostic testing, such as spirometry or laboratory investigation

‡ The differences in proportions of patient management after chest radiography were significant with a p-value ≤ 0.05

FIGURE 1. Distribution of the probabilities of pneumonia estimated by the general practitioners before and after chest radiography

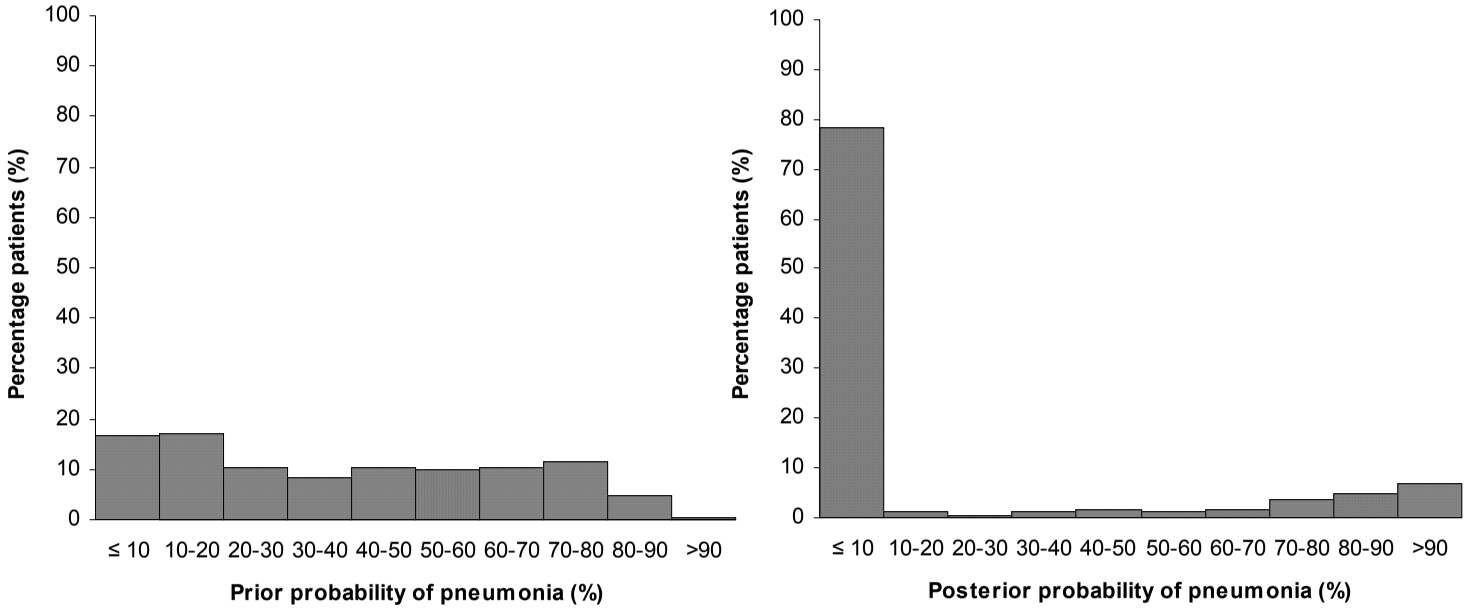

FIGURE 2. Flow diagram with the number of patients with a low, moderate or high probability of pneumonia according to the GP before and after CXR