

Community-acquired pneumonia in primary care: clinical assessment and the usability of chest radiography

A.B. Moberg^{a,e}, U. Taléus^{b,e}, P. Garvin^{c,e}, S.-G. Fransson^d and M. Falk^{a,e}

^aKärna Vårdcentral, Linköping, Sweden; ^bLjungsbro Vårdcentral, Ljungsbro, Sweden; ^cResearch and Development Unit for Local Health Care, County of Östergötland, Linköping, Sweden; ^dDepartment of Medical and Health Sciences, Division of Radiological Sciences, University of Linköping, Linköping, Sweden; ^eDepartment of Medical and Health Sciences, Division of Community Medicine, Primary Care, University of Linköping, Sweden

ABSTRACT

Objectives: To investigate the diagnostic value of different clinical and laboratory findings in pneumonia and to explore the association between the doctor's degree of suspicion and chest X-ray (CXR) result and to evaluate whether or not CXR should be used routinely in primary care, when available. **Design:** A three-year prospective study was conducted between September 2011 and December 2014. **Setting:** Two primary care settings in Linköping, Sweden. **Subjects:** A total of 103 adult patients with suspected pneumonia in primary care. **Main outcome measures:** The physicians recorded results of a standardized medical physical examination, including laboratory results, and rated their suspicion into three degrees. The outcome of the diagnostic variables and the degree of suspicion was compared with the result of CXR. **Results:** Radiographic pneumonia was reported in 45% of patients. When the physicians were sure of the diagnosis radiographic pneumonia was found in 88% of cases ($p < 0.001$), when quite sure the frequency of positive CXR was 45%, and when not sure 28%. Elevated levels of C-reactive protein (CRP) ≥ 50 mg/L were associated with the presence of radiographic pneumonia when the diagnosis was suspected ($p < 0.001$). **Conclusion:** This study indicates that CXR can be useful if the physician is not sure of the diagnosis, but when sure one can rely on one's judgement without ordering CXR.

KEY POINTS

- There are different guidelines but no consensus on how to manage community-acquired pneumonia in primary care.
- When the physician is sure of the diagnosis the judgement is reliable without chest X-ray and antibiotics can be safely prescribed.
- Chest X-ray can be useful in the assessment of pneumonia in primary care, when the physician is not sure of the diagnosis.

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Introduction

One of the most common reasons for consulting in primary healthcare is acute cough and lower respiratory tract symptoms. Lower respiratory tract infections (LRTIs) include acute bronchitis and pneumonia. Bronchitis is considered a viral disease that is self-limiting in most cases and expectant management is recommended whereas pneumonia, which is a more serious condition, calls for antibiotic therapy, since it is of bacterial aetiology and may be fatal even in young adults.[1–3] In the European community the mortality of community-acquired pneumonia (CAP) is less than 1%. Mortality is higher among hospitalized patients, increases with age,

and is higher among men.[4–6] The annual incidence of CAP in Europe is 5–8/1000 residents, of which nearly 80% are managed in primary care.[5,6] The prevalence of radiographic pneumonia in outpatients with LRTI has been reported to range between 5% and 21% depending on inclusion criteria.[7–12] The most common aetiology of CAP, seen in primary care, is *Streptococcus pneumoniae*. [5,10,11,13] As a consequence of extensive antibiotic use, the incidence of multidrug-resistance has increased alarmingly and up to 30% of *S. pneumoniae* worldwide are now considered as multidrug-resistant.[14] It is therefore essential for the general practitioner (GP) to correctly identify and treat patients with pneumonia and leave those with acute bronchitis

without antibiotic prescription. However, pneumonia in outpatients may be difficult to diagnose, and several studies have aimed to pinpoint typical manifestations of the diagnosis with varying results.[9,15–17] Chest X-ray (CXR) is considered the gold standard for diagnosis of pneumonia.[18] The Infectious Diseases Society of America suggests CXR in all cases of suspected pneumonia whereas European guidelines recommend that chest radiography should be considered in the case of persisting doubt after C-reactive protein (CRP) testing to confirm or reject the diagnosis.[1,18] However, while CRP quantification is a widely used near-patient test to differentiate serious from more trivial self-limiting conditions, CXR is not always available in primary care. Thus, the gold standard on how to diagnose CAP in primary care does not always apply. In Sweden the recommendation in the assessment of community-acquired pneumonia is not to use CRP or CXR routinely, in the initial judgement, but to base diagnosis on clinical manifestations.

Swedish guidelines criteria for possible pneumonia are:

- Generally ill patient often with tachypnoea $> 20/\text{min}$ and tachycardia $> 120/\text{min}$ and symptoms such as: fever, cough, newly expressed fatigue, and lateralized breath pain.
- Common clinical findings: focally depressed or altered breathing sounds (crackles or wheezes) or dullness to percussion.[19]

The aims of the present study were to investigate the diagnostic value of different clinical and laboratory assessments used in general practice when suspecting pneumonia. Specifically we aimed to explore the association between the doctor's degree of suspicion and CXR result and to evaluate whether or not pulmonary chest radiography should be used routinely in primary care, when CXR is available.

Materials and methods

Participants

A sample size calculation was made a priori, using conventional limit values of a statistical power of at least 80% and significance level of 95%. Based on an assumption of a 65/35 proportion in presence or absence of clinical or laboratory variable outcome between patients with and without radiographic pneumonia, approximately 100 patients were required. The study was conducted from September 2011 to December 2014. One hundred and three patients, who visited either of two participating primary care centres during the study period, were consecutively included. The inclusion criteria were: the doctor's suspicion of

pneumonia, age ≥ 18 years, and respiratory tract infection symptoms for more than 24 hours. Pregnancy, known chronic obstructive pulmonary disease, and patients living in nursing homes were exclusion criteria. Recent antibiotic prescription was not originally set as an exclusion criterion, but when starting analysing the material a decision was made to exclude patients who had received antibiotics for LRTI within less than two weeks. The study was carried out during regular working hours. The patients were examined by GPs or resident physicians. All participants gave written informed consent and the regional ethical review board in Linköping, Sweden approved the study.

Measurements

When the physicians in the initial consultation with the patient with LRTI suspected pneumonia they were asked to document anamnestic data and findings from the physical examination. The documentation was done according to Swedish guidelines, with the exception of rhonchi, which was not recorded. As the study was conducted in Sweden we used the established Swedish terminology for breath sounds routinely used in clinical practice, covering "rales" (coarse crackling sounds) and "crepitations" (fine crackling respiratory sounds), as well as decreased breath sounds and dullness to percussion. Anamnestic data and other clinical findings by means of lateralised chest pain, body temperature (measured by a digital ear thermometer), breathing frequency, pulse, and blood oxygen saturation were also recorded. The documentation was done according to Swedish guidelines, except for rhonchi that were not documented. Capillary blood samples for CRP (Quick Read Go™, Orion Diagnostics Oy, Sweden) and white blood cell count (WBC) (Swelab Alfa™, Boule Medical AB, Sweden) were drawn from all patients and were analysed using standard procedures. When the results from the blood samples were available, the physicians rated their suspicion of pneumonia into three categories: sure, quite sure, and unsure. The degree of suspicion was recorded and a CXR was requested thereafter. All the patients were admitted for a CXR, frontal and lateral views, within 48 hours. The radiologist received all relevant anamnestic and clinical information and the inquiry was "pneumonia?" or "new infiltrate?". Each examination was viewed by the radiologist on duty who also gave a written preliminary answer. The examinations were later viewed once more and a definitive statement was signed by a board-certified radiologist according to clinical routine.

Positive radiographic findings were defined as the presence of a new infiltrate in the definitive statement.

Doubtful radiographic findings interpreted as “possible pneumonia” were considered positive cases as this is how it would be categorized in the clinical context, given the physician’s initial suspicion of pneumonia.

Physicians were free to decide on treatment before or after the result of CXR, and follow-up was performed when judged appropriate. Thus, the physicians were not blinded to the outcome of CXR.

Twenty physicians participated in the study; 55% were general practitioners and 45% were resident physicians.

Statistics

The diagnostic variables were evaluated comparing the CXR outcome “pneumonia” with “no pneumonia”. Continuous data in anamnestic, clinical, and laboratory variables were dichotomized. The cut-off value for CRP was set at ≥ 50 mg/L as it has been shown to be a significant level for radiographic pneumonia [7,10] and has been used in previous studies.[8–10,20] Additionally, however, we made subgroups of CRP: <20 , $20\text{--}49$, $50\text{--}100$, >100 for analyses.

The cut-off value for body temperature was set to $\geq 38^\circ\text{C}$.

Means were compared using a t-test. Pearson’s chi-square test was used for crude group comparisons. If the expected count was less than 5, in any cell, Fisher’s exact test was used. Odds ratios were calculated with 95% confidence intervals. A logistic regression model with stepwise backward elimination was performed to determine which variables were associated with positive CXR in a multiple analysis. This was done in two runs (using standard criteria for removal in both), first including all the diagnostic variables (anamnestic, physical examination, and laboratory analyses), then including all diagnostic variables except for CRP and WBC.

Evaluation of ordinal trend in degree of suspicion in relation to CXR outcome was performed using linear-by-linear association.

A p value <0.05 was considered statistically significant.

Data management and statistical analyses were performed using IBM SPSS Statistics™, version 22 (IBM Corp. NY, USA).

Results

Of the 103 patients recruited, three were excluded; one because of missing CXR and the other two since they were already diagnosed with pneumonia, and had been treated with antibiotics less than two weeks earlier. Thus, 100 patients, where the physician suspected pneumonia, entered the study. The mean age was 56

years (SD 17); 45% were men and 55% were women. Among men the mean age was 58 years, and among women 55 years.

Some 12% were current smokers. All patients were Caucasians.

During the study period approximately 300 patients were diagnosed with pneumonia, calculated from the amount of registered doctor’s visits. Totally there were 41 470 registered visits, and 1011 with acute bronchitis.

In eight of the CXR the answer was “possible infiltrate”. In those the CRP levels ranged between 69 and 117 mg/L.

A total of 45% of the patients in the study had radiographic pneumonia. The mean CRP concentration in the study population was 68 mg/L. In those with radiographic pneumonia the mean value of CRP was 94 mg/L and in those without positive CXR the mean value was 47 mg/L ($p<0.001$). The mean temperature was 37.5°C ; 37.7°C in those with positive CXR and 37.3°C in those without ($p<0.05$). We found no difference between men and women in these groups. As seen in Table 1, 82% of the patients with radiographic pneumonia had a CRP-level ≥ 50 mg/L. Radiographic pneumonia was significantly positively associated in crude analyses with CRP-level ($p<0.001$), body temperature ($p<0.05$), and rales ($p<0.05$). When adjusting for covariates in a multiple logistic regression model using stepwise backward elimination, the significance for CRP remained ($p<0.001$) but body temperature and rales became non-significant. In a similar model, starting with all variables in Table 1 except for laboratory analyses (CRP and WBC), body temperature was significantly associated with CXR outcome ($p<0.05$) (data not shown).

Being a current smoker was negatively correlated with radiographic pneumonia when analysed in the multiple logistic regression model (see Table 1).

CRP levels in relation to CXR outcome are presented in Figure 1. In this material, comprising only patients with suspected pneumonia, PPV (positive predictive value) for CRP >50 mg/L was 65% and NPV (negative predictive value) was 81%.

The proportions of the clinical suspicion degrees as well as outcome of CXR and antibiotic prescribing are given in Table 2. In two of the patients the report of suspicion was lacking and had to be collected afterwards. In both cases the physician was unsure of the diagnosis.

The degree of suspicion was strongly associated with elevated CRP levels (Figure 2) as well as the presence of positive CXR ($p<0.001$) (Figure 3). There was no correlation between body temperature and the degree of suspicion. CRP levels <10 mg/L were found in 17

Table 1. Association between different diagnostic variables including clinical findings, laboratory findings, and anamnestic data, and radiographic pneumonia in primary care showing the crude and adjusted OR for having radiographic pneumonia.

Diagnostic variable	Data missing, n (%)	Total (n = 100), n (%)	Positive CXR (n = 45), n (%)	Negative CXR (n = 55), n (%)	p-value	OR (95% CI)	
						Crude ¹	Adjusted ²
Men	0 (0.0)	45 (45.0)	17 (37.8)	28 (50.9)	0.189	0.6 (0.3–1.3)	1.9 (0.6–6.3)
Current smoker	2 (2.0)	12 (12.0)	3 (6.7)	9 (17.0)	0.137*	0.3 (0.9–1.4)	0.1 (0.0–0.9)
Lateralized chest pain	4 (4.0)	17 (17.7)	7 (16.3)	10 (18.9)	0.741	0.8 (0.3–2.4)	0.9 (0.2–4.7)
Crackles	0 (0.0)	48 (48.0)	21 (46.7)	27 (49.1)	0.809	0.9 (0.4–2.0)	1.1 (0.3–3.4)
Rales	0 (0.0)	23 (23.0)	15 (33.3)	8 (14.5)	0.026	2.9 (1.1–7.8)	3.2 (0.8–13.1)
Decreased breath sounds	1 (1.0)	23 (23.2)	9 (20.5)	14 (25.5)	0.558	0.8 (0.3–1.9)	0.8 (0.2–3.8)
Dullness to percussion	3 (3.0)	15 (15.5)	5 (11.6)	10 (18.5)	0.351	0.6 (0.2–1.8)	0.3 (0.0–2.3)
Body temperature (> 38 °C)	1 (1.0)	21 (21.2)	15 (33.3)	6 (11.1)	0.007	4.0 (1.4–11.4)	3.3 (0.7–14.8)
Tachypnoea (> 20 breaths/min)	4 (4.0)	55 (57.3)	26 (60.5)	29 (54.7)	0.571	1.3 (0.6–2.9)	0.8 (0.2–2.7)
Tachycardia (pulse > 100 beats/min)	2 (2.0)	28 (28.6)	13 (29.5)	15 (27.8)	0.847	1.1 (0.5–2.6)	1.1 (0.3–4.0)
Desaturation (< 95%)	0 (0.0)	26 (26.0)	14 (31.1)	12 (21.8)	0.292	1.6 (0.7–4.0)	1.2 (0.3–4.7)
CRP (> 50 mg/L)	0 (0.0)	57 (57.0)	37 (82.2)	20 (36.3)	<0.001	8.1 (3.2–20.7)	10.9 (3.0–39.2)
Leukocytosis (> 15 x 10 ⁹ /L)	2 (2.0)	12 (12.2)	7 (15.9)	5 (9.3)	0.318	1.9 (0.5–6.3)	1.0 (0.2–6.5)

Notes: *Fisher's exact test. ¹Chi-square test. OR calculated using Mantel–Haenzel equation. ²Multiple logistic regression model, stepwise backward elimination. All variables are in the table

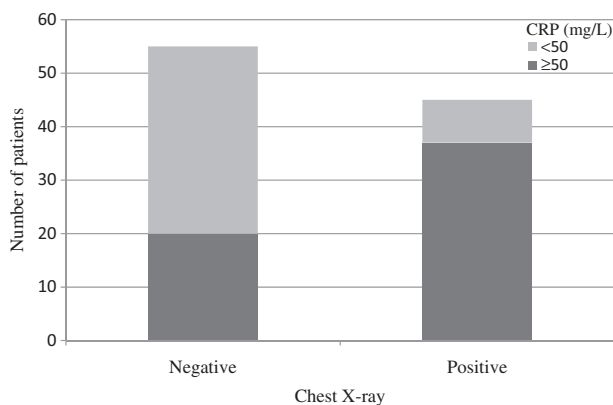


Figure 1. CRP in relation to outcome of chest X-ray. Positive chest X-ray is defined as radiographic pneumonia.

patients (17%), where one of them had a new infiltrate on CXR. In two of the patients CRP was < 50 mg/L and still the degree of suspicion was high. When looking at the results, CXR was positive in both cases.

Linear-by-linear association was performed to the ordinal trend for degree of suspicion and outcome of radiography ($p < 0.001$). When looking at PPV for the term "sure" this was 88% and NPV was 62%.

When CRP levels were divided into subgroups the degree of suspicion did not differ between CRP < 20 mg/L and 20–49 mg/L, nor between CRP 50–100 mg/L and > 100 mg/L. When CRP was < 20 mg/L only 18% were prescribed antibiotics and 25% of those cases had a positive CXR. When CRP was 20–49 mg/L, 71% were prescribed antibiotics. All of the patients presenting with CRP > 100 mg/L were prescribed antibiotics. Of all the patients included in the study, 76% were prescribed antibiotics.

Discussion

Of our 100 patients only 45% had radiographic pneumonia. This is in line with a primary-care based study by Blaeuer et al.,[21] but differs from the results presented by Vugt et al., who found radiographic pneumonia in 57% of patients with clinically suspected pneumonia.[22]

Our main finding was that the physician's degree of suspicion was strongly associated with the presence of a new infiltrate on CXR. In particular, a high degree of suspicion for pneumonia corresponds well with a positive CXR. To our knowledge, this has not been shown before. Of the other investigated anamnestic, clinical, or laboratory variables only CRP, rales, and body temperature were positively associated with CXR. Of note is that current smoking was negatively associated with CXR in the adjusted models. We believe this is an effect of unhealthy selection out of exposure in the study population, as the prevalence of current smokers is lower in the study population than in a normal Swedish population. The odds ratio in this setting should not be confused with evaluation of smoking as a risk factor for new infiltrate.

CRP as a single predictor of CAP in patients with respiratory symptoms has been debated and evaluated in several studies.[7,23,24] Our findings on elevated CRP levels in relation to CAP corroborate previous findings,[7,10,23,24] but are in contrast to Lagerström et al. who concluded routine use of CRP to be of limited value when diagnosing CAP in primary care.[25] It has been shown earlier that the diagnostic value of CRP increases when combined with clinical assessment.[7,26] In that light, it is noteworthy that for two of the patients CRP was < 50 mg/L but the degree of suspicion was high. When looking at the results, CXR

Table 2. Proportions and outcomes of chest X-ray and antibiotic prescribing in relation to clinical judgement, by means of degree of suspicion of pneumonia.

	Positive CXR	Antibiotics prescribed	No antibiotics prescribed	Positive CXR (% of those with antibiotics)	Negative CXR (% of those without antibiotics)
Unsure (n = 43)	12 (28%)	54% (n = 23)	46% (n = 20)	52%	100%
Quite sure (n = 40)	18 (45%)	93% (n = 37)	7% (n = 3)	49%	100%
Sure (n = 16)	14 (88%)	94% (n = 15)	6% (n = 1)	93%	0%

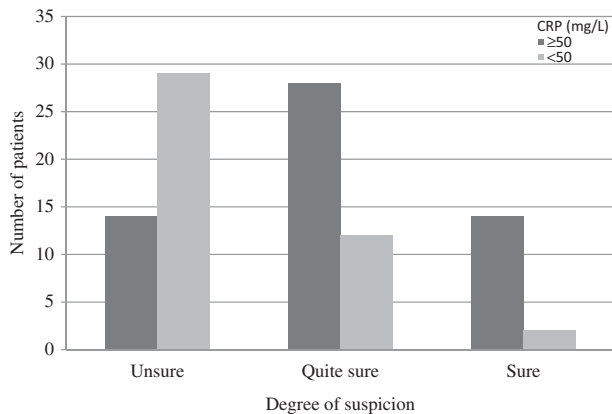


Figure 2. CRP in relation to clinical judgement by means of degree of suspicion of pneumonia.

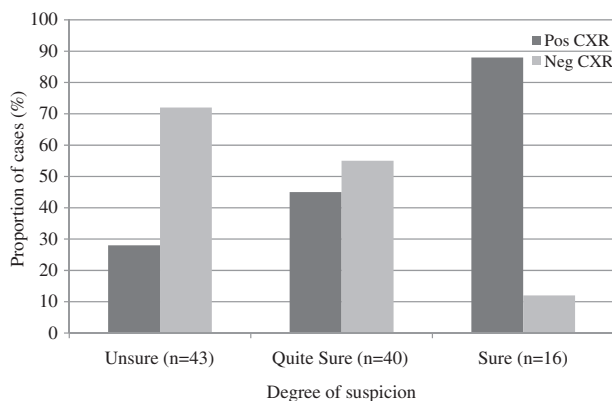


Figure 3. Clinical suspicion of pneumonia in primary care and outcome of chest radiography.

was positive in both cases. Thus, while degree of suspicion was associated with CRP level, there is additional value in the clinical judgement based on the general impression of the patient, to determine degree of suspicion and consequently to diagnose pneumonia. We assume that routine use of CRP is of value for clinical assessment, but when the physician is not sure of the diagnosis CXR can be helpful regardless of the CRP level.

As the physicians had some degree of suspicion of pneumonia for every patient included, we might speculate that all patients would have been treated with

antibiotics if they were not X-rayed. Probably, a few of the patients would have been X-rayed even without the study, and, in the case of negative CXR, would not have been prescribed antibiotics. On the other hand the study design gave the physicians an opportunity to prescribe antibiotics either before or after CXR result. It may be that the extent of antibiotics prescribed would have been reduced further if all the decisions on antibiotic prescription had been made after CXR result. Judging from the prescription pattern in the study material, the indication to initiate antibiotic treatment was reduced by 24%. We assume that the decision to refrain from antibiotic treatment was made after receiving the results of CXR. If so, routine use of CXR could contribute to reduced prescription of antibiotics and thereby reduce the development of resistance in *S. pneumoniae*. It would be interesting to examine whether directed use of CXR, i.e. when the physician is unsure or quite sure of the diagnosis, could reduce the prescription of antibiotics.

We found a frequency of 88% positive CXR in cases where the physician was sure of the diagnosis and 45% when quite sure. The results differ from the study by Speets et al. who identified radiographic pneumonia in 50% of patients when the probability of the diagnosis was high. However, they included patients only when history and physical examination did not provide sufficient information for a diagnosis of pneumonia.[27]

The many different guidelines on how to diagnose CAP [1,2,20] can be confusing. In a recent study by Friis Christensen et al. marked differences were found regarding the GP's diagnostic criteria for pneumonia comparing Danish and Spanish physicians' judgements. In Spain the use of CXR was much more frequent and resulted in diagnosis of pneumonia in only 11% of LRTI patients, in contrast to Denmark where the physician relied on CRP level and where 47% of the patients were classified with the diagnosis.[8] Speets et al. have shown that CXR affects patient management including reduced use of antibiotics.[27] Thus, there are obvious reasons to believe that antibiotics are overprescribed when CXR is not used.

The main limitation in the study is that duration of symptoms was not recorded. One of the inclusion criteria was symptoms lasting more than 24 hours but

we have no information on the exact duration of illness. As this is likely to have an impact on CRP levels, interpretations of CRP as a single variable should be treated with caution. This limitation does not, however, devalue the main finding “degree of suspicion” in relation to CXR.

Another limitation is that the degree of suspicion was rated only after the CRP results, but not before. Thus we do not know to what extent the CRP result affected the degree of suspicion. On the other hand the fact that PPV for CRP ≥ 50 mg/L was much lower than PPV for the term “sure” might indicate that clinical examination adds important complementary information.

Furthermore, it is possible that some of the patients suffered from pneumonia despite a negative CXR. It has been shown that, among inpatients, a radiographic infiltrate can occur later according to progression of the disease.[28] Some pneumonia patients might have been missed among those with LRTI, as we know from earlier studies that GPs make clinical judgements of pneumonia in a minority of patients.[16,22,29] Another limitation was that the physicians participated on a voluntary basis and did not get extra time for the consultations. This could have affected the number and/or skewed the selection of recruited patients, as many patients with suspected pneumonia were not included in the study. Further, we do not know how many patients rejected participation, or if they systematically had more severe or milder symptoms than the participants.

The major strength of this study is that it reflects routine clinical work, aiming to improve clinical judgement in a setting where guidelines do not conform. All patients underwent CXR regardless of the physician’s clinical assessment and the physician received the results from CXR, but the study design gave an opportunity for the physicians to treat the patients before or after the CXR results were obtained.

Chest radiography could be useful when the physician suspects pneumonia but is not sure of the diagnosis. On the other hand, if the physician is sure of the diagnosis, there seems to be no apparent need for CXR as the clinical judgement appears to be a reliable and sufficient diagnostic tool whereby antibiotics should be prescribed. Applying this strategy is likely to enhance avoidance of unnecessary antibiotic treatment and in extension counteracts the increase of bacterial resistance.

Further studies should be performed to examine which factors have an influence on the degree of suspicion, and to what extent CRP result affects the degree of suspicion, to establish evidence-based criteria

for the diagnosis of pneumonia and the use of chest radiography in primary care.

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Disclosure statement

The authors declare that no conflict of interest exists.

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