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ARTICLE

Community-acquired pneumonia: impact of empirical antibiotic therapy without respiratory fluoroquinolones nor third-generation cephalosporins

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Abstract Guidelines for inpatients with community-acquired pneumonia (CAP) propose to use respiratory fluoroquinolone (RFQ) and/or third-generation cephalosporins (Ceph-3). However, broad-spectrum antibiotic therapy is associated with the emergence of drug-resistant bacteria. We established a guideline in which RFQ and Ceph-3 were excluded as a first course. Our aim was to evaluate the impact of our therapeutic choices for CAP on the length of hospital stay (LOS) and patient outcome. This was a cohort study of patients with CAP from July 2005 to June 2014. We compared patients benefiting from our guideline established in 2008 to those receiving non-consensual antibiotics. Disease severity was evaluated through the Pneumonia Severity Index (PSI). The empirical treatment for PSI III to V was a combination therapy of amoxicillin–clavulanic acid (AMX-C)+roxithromycin (RX) or AMX+ofloxacin. Adherence to guidelines was defined by the prescription of one of these antibiotic agents. Requirement for intensive care or death defined unfavorable outcome. Among 1,370 patients, 847 were treated according to our guideline (61.8 %, group 1) and 523 without concordant therapy (38.2 %, group 2). The mean PSI was similar: 82 vs. 83, $p>0.5$. The mean LOS was lower in group 1: 7.6 days vs. 9.1 days, $p<0.001$. An unfavorable outcome was less frequent in group 1: 5.4 % vs. 9.9 %, $p=0.001$. In logistic regression models, concordant therapy was associated with a favorable outcome: adjusted odds ratio (AOR) [95 % confidence interval (CI)] 1.85 [1.20–2.88], $p=0.005$. CAP therapy without RFQ and Ceph-3 use was associated with a shorter LOS and fewer unfavorable outcomes.

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Introduction

Community-acquired pneumonia (CAP) is a common illness that can require emergency care [1–3]. Indeed, severe CAP is associated with a significant morbidity and with an estimated 30 day-mortality rate of over 20 % [4, 5].

The significant mortality rate of CAP justifies the need to develop strategies and guidelines across the world [6–8]. The favorable impacts of these guidelines have been reported, indicating that observance is associated with a shorter length of hospital stay (LOS), lower requirement for intensive care, as well as a reduction in mortality [9–13].

However, differences exist between guidelines, mostly due to regional differences in causative agents and local bacterial resistance to antibiotics [6, 12]. Accordingly, North American guidelines indicate the importance of locally adapting CAP management guidelines [6]. If *Streptococcus pneumoniae* is always the key pathogen responsible for CAP, the prevalence of other pathogens, such as *Legionella pneumophila* or *Pseudomonas aeruginosa*, may vary [6–8, 14, 15]. Also, the varying susceptibility of *S. pneumoniae* to penicillin around the world and the frequency of Gram-negative bacilli as causative agents of CAP in the elderly have both led to propose third-generation cephalosporins (Ceph-3) and either a macrolide or a fluoroquinolone in case of severe CAP [6–8]. A respiratory quinolone (RFQ) is also regularly proposed as an alternative regimen, especially in case of β-lactam-allergic patients. Lastly, RFQ have proved their effectiveness as a single treatment for CAP, both for outpatients and for the severe form requiring intensive care [16].

These therapeutic recommendations appear as broad-spectrum antibiotic therapy, which contributes to the

emergence of multiresistant bacteria (MRB) [17–19]. It is noteworthy that these antibiotics, RFQ and Ceph-3, are associated with the rise of extended-spectrum β-lactamase (ESBL) enzymes produce by Enterobacteriaceae [20, 21]. Fluoroquinolone use was also associated with the rate of *Staphylococcus aureus* resistant to methicillin [22]. Thus, French antimicrobial stewardship programs include recommendations for a restricted use of fluoroquinolones and Ceph-3 [23].

Taking into account the current level of antibiotic resistance for respiratory pathogens in France [24, 25], we thought that our locally implemented therapeutic guideline for CAP could avoid these molecules, RFQ and Ceph-3, at least as a first-line empirical treatment. Our aim was to evaluate the clinical impact of these unusual therapeutic choices with emphasis on LOS and in-hospital mortality rate.

Patients and methods

Population and study design

This is an observational cohort study realized in Nice University Hospital, a 1,600-bed tertiary care center with a single Infectious Diseases Department that serves a population of about 600,000 people.

The cohort is based on our medical dashboard put into practice since July 2005, the inclusion period continuing to the end of June 2014.

To create this medical dashboard, we first simplified the conclusions of the patient charts using a consensual and systematic plan. Working with StatView® software, our file integrates 28 parameters of all hospitalized patients, including demographic data, clinical diagnosis, relevant microbiological information, antibiotic therapy, LOS, and outcome [26]. The Pneumonia Severity Index (PSI) is specifically recorded for CAP.

Comorbidities are reported in the dashboard if the patient received specific treatment before hospital care or if the diagnosis is newly established during the hospital stay.

Finally, we translate the specific final diagnosis in disease-related groups (DRG) defined by the site of infection. As the software allows diagnosis or DRG selection, it is easy to study the main patient characteristics and evolution of a specific disease.

The accuracy of our database is verified through eight steps [26]. Previous analysis showed that we needed to specifically verify in the patient charts the accuracy of the PSI and the reasons for non-consensual antibiotic therapy [28]. The latter fell into six groups: microbial, allergy, coinfection, immunodepression, comorbid conditions, and others.

The inclusion criteria were adult patients with a primary discharge diagnosis of CAP as suggested by the following medical terms in the dashboard: pneumonia, bronchopneumonia, pleuropneumonia. The acquisition of the disease in the community setting is specified in the dashboard; CAP in the presence of human immunodeficiency virus (HIV) disease were included.

Exclusion criteria were nosocomial infection defined by a diagnosis established≥48 h after hospital admission, acute bronchitis, exacerbation of chronic obstructive pulmonary disease (COPD), tuberculosis, opportunistic infections (pneumococcal pneumonia in the context of HIV infection was not considered as opportunistic in nature), and pulmonary infections in granulopenic patients (less than 1,000 leukocytes/mm^3).

Unfavorable outcome was defined as the requirement for intensive care after antibiotic initiation in our department or death. All patient charts were retrospectively analyzed in order to determine the cause(s) of death. Causes of death were classified into four categories: related to infectious diseases (septic shock, multiple-organ failure, acute respiratory distress syndrome), comorbid conditions, limitation of treatments, and others.

Our internal guideline was established in September 2008 after a first set of analyses from our database suggesting first a large heterogeneity in the antibiotic prescription in CAP [27], and second the potential of narrow-spectrum antibiotic therapy in front of positive urinary antigen testing for *Legionella* or *S. pneumoniae* [28]. We consensually chose to avoid Ceph-3 and RFQ as the first empirical antibiotic therapy for CAP. However, ofloxacin was given in association with amoxicillin in case of severe CAP without documented microbial etiology, as some of us thought that this molecule was better than roxithromycin against *Legionella*.

The empirical therapy for PSI I and II was amoxicillin (AMX) or AMX+clavulanate (AMX-C) or roxithromycin (RX). For PSI III to V, a combination therapy AMX-C+RX or AMX+ofloxacin was proposed. Regarding the main documented infections, AMX was indicated for *Pneumococcus* infection and RX for legionellosis. Levofloxacin was the alternative agent in case of β-lactams allergy. We also had to differently consider patients with CAP without previous adequate antibiotic treatment and those with CAP and a failure of an adequate antibiotic treatment. In the latter case, chest computed tomography (CT) scan as well as endoscopic microbial investigations were suggested and *P. aeruginosa* and/or methicillin-resistant *S. aureus* infection have to be considered when choosing the empirical antibiotic therapy.

The availability of our consensus was based on the document to hand in the medical rooms, as well as through the use of a pocketbook.

Guideline concordance was defined as the prescription of a recommended antibiotic molecule throughout the treatment period, without consideration for the route of administration nor the posology. Of note, we have used high-dose AMX

(e.g., 1 to 2 g, three times daily, depending on the patient's weight) in practice for more than a decade. Accordingly, if more than one course of antibiotic therapy was prescribed, the whole treatment was considered as recommended if successive prescribed molecules were cited in the internal guideline. As an example, a first empirical treatment for severe pneumonia containing AMX-C+RX modified after *Klebsiella pneumoniae* identification in a respiratory sample with RX removal was considered in accordance with our guideline.

Microbial investigations

Bacteriological investigations included blood cultures before the administration of antibiotics and systematically urinary antigen testing for *L. pneumophila* and *S. pneumoniae*, regardless of the severity of the disease. The results of such urinary tests have been obtained in routine use in less than 4 h for more than 10 years, allowing early directed antibiotic therapy [27–29]. A respiratory specimen was also expected, regardless of the technique used, including bronchoalveolar lavage, considering that two senior physicians of our team are also pneumologists. Routine serological investigation for *Mycoplasma pneumoniae*, *Chlamydophila pneumoniae*, *L. pneumophila*, and *Coxiella burnetii* were also performed if the first set of microbiological tests were negative.

Statistical analysis

Data were analyzed with StatView software version 4.5 and statistical significance was established at $\alpha=0.05$. Continuous variables were compared with the Student's *t*-test or the Mann–Whitney non-parametric test. Proportions were compared with the χ^2 statistic or Fisher's exact test when appropriate. Logistic regression was used for multivariate analysis of the impact of guideline concordance on the all-cause in-hospital mortality, and the results are presented as adjusted odds ratios (AORs), along with their 95 % confidence intervals (CIs). Variables were selected as candidates for the multivariate analysis on the basis of the level of significance of the univariate association with in-hospital mortality ($p<0.1$). Models were built up sequentially, starting with the variable most strongly associated with the outcome and continuing until no other variable reached significance or altered the odds ratios of variables already in the model. When the final model was reached, each variable was omitted in turn in order to assess its effect.

Results

Over the 9-year study period, 1,370 patients with CAP were hospitalized. We observed more antibiotic prescriptions in accordance with the guideline after September 2008, 504/732 (68.8 %) compared to 343/638 (53.7 %), $p<0.001$. However, as our main goal was to find out the impact of our therapeutic choice on LOS and outcome, we compared all patients treated accordingly to others, whatever the considered period. Thus, 847 patients were treated in accordance with our therapeutic option (61.8 %, group 1) and compared to 523 patients who were not (38.2 %, group 2).

Table 1 shows the main characteristics of the patients. Patients from group 1 showed a trend towards more HIV infection and alcoholism, while patients from group 2 presented with significantly more tumoral diseases and/or immune alterations other than HIV infection. It should be noted that pulmonary diseases, including COPD and active smoking, were equally distributed among these groups of patients. Also, the severity of the disease was similar between groups, as indicated by the PSI.

Microbiological data are also indicated, the infection being documented in 607 cases (44.3 %). Blood cultures were performed in 89 % of the cases, being positive in 6.0 %. All patients benefited from urinary antigen tests. As expected, *S. pneumoniae* was the most frequently isolated pathogen in this community setting and was associated with a higher level of guideline observance, in contrast to *Legionella* infection. *P. aeruginosa* not included in the antibacterial spectrum of our consensual first course of antibiotics was logically associated with other antibiotic therapy.

The main antibiotic courses are listed in Table 2. As suggested, the observance of our therapeutic choice was associated with the prescription of a single course of therapy ($p<0.001$). Twelve patients who were allergic to penicillin were prescribed levofloxacin. Among 95 patients benefiting from roxithromycin treatment, no *Pneumococcus* infection was diagnosed, this molecule being mainly prescribed for *Legionella* infection or atypical pathogens.

The patient chart analysis showed an explanation for non-adherence to the guideline in 117/523 cases (22.4 %). Reasons for this were microbiological data (64 %), allergy (10 %), immune depression (12 %), coinfection (8 %), comorbid conditions (3 %), and others (3 %).

A total of 98 patients presented with an unfavorable outcome (7.1 %), among whom 26 were transferred to the intensive care unit (ICU) and 72 died. The unfavorable outcome occurred before 48 h spent in the hospital for 26 patients. The causes of death are detailed in Table 2, being mainly related to respiratory infections or comorbid conditions.

Patients with unfavorable outcome were compared to the others presenting with favorable outcome in a univariate analysis (see Table 3). Age, comorbid conditions, PSI score, microbiological data, and adherence to our therapeutic choice were associated with an unfavorable outcome. However, the multivariate analysis found only three risk factors associated with an unfavorable outcome. As expected, the PSI score was

Table 1 Comparability of the study groups, depending on the observance of the internal guideline. Univariate analysis

	Group 1 n=847 (61.8 %)	Group 2 n=523 (38.2 %)	p-Value
Age (years)	65±18	65±19	0.367
Sex ratio (M/F)	1.45	1.58	0.438
Comorbid conditions			
Cardiovascular	311 (36.9)	193 (36.7)	0.945
Chronic heart failure	42 (4.6)	24 (4.9)	0.752
Diabetes	121 (14.3)	72 (13.7)	0.788
Neurological and/or psychiatric	213 (25.1)	111 (21.2)	0.096
Pulmonary	224 (26.4)	139 (26.6)	0.957
COPD	78 (8.2)	47 (8.9)	0.889
Active smoking	111 (13.1)	65 (12.4)	0.716
Cancers/immunodepression	41 (4.8)	51 (9.7)	<0.001
HIV infection	85 (10.5)	37 (7.2)	0.047
Alcoholism	72 (8.5)	31 (5.9)	0.079
Liver diseases	117 (13.8)	64 (12.2)	0.402
Chronic renal failure	66 (7.8)	44 (8.4)	0.681
Aspiration pneumonia	78 (9.2)	44 (8.4)	0.615
PSI score	82±32	83±33	0.633
PSI<3	307 (36.4)	193 (37.4)	0.726
PSI 3	212 (25.2)	126 (24.4)	0.753
PSI 4	257 (30.5)	156 (30.2)	0.910
PSI 5	66 (7.8)	41 (7.9)	0.943
Microbial data			
Documented infection	337 (39.8)	270 (51.6)	<0.001
Blood culture performed	755 (89.8)	462 (89.2)	0.732
Positive blood culture	48 (5.7)	35 (7.0)	0.439
Polymicrobial respiratory sample	300 (35.4)	229 (43.8)	0.002
Main bacterial pathogens from monomicrobial respiratory samples*			
Streptococcus pneumoniae	184 (21.7)	68 (13.0)	<0.001
*Legionella pneumophila***	35 (4.1)	63 (12.0)	<0.001
Enterobacteriaceae	21 (2.5)	39 (7.4)	<0.001
Haemophilus influenzae	20 (2.4)	18 (3.4)	0.236
Staphylococcus aureus	11 (1.3)	15 (2.9)	0.064
Pseudomonas aeruginosa	6 (0.7)	13 (2.5)	0.006
Atypical pathogens	25 (2.9)	16 (3.0)	0.909
Influenza virus	28 (3.3)	5 (0.9)	0.005

*From standard isolation procedures (sputums, bronchoalveolar lavages, bronchic aspirations)

**All *Legionella* infections had a positive antigen urinary test

the main risk factor associated with unfavorable outcome, followed by *P. aeruginosa* infection (Table 4). Fourteen out of 32 *Pseudomonas* infections (44 %) benefited from an anti-*Pseudomonas* compound as the first-line therapy, and 6/32 benefited from specific treatment as a second-line therapy. There was no relationship between adequate anti-*Pseudomonas* antibiotic compound and outcome (data not shown). Finally, our therapeutic choice appeared to be a protective factor: AOR [95 % CI]: 0.538 [0.347–0.833], p=0.005. Moreover, taking into account that antibiotic therapy must be active for at least 48 h before positively impacting the prognosis, we analyzed patients presenting an LOS>2 days (n=1,295): guideline concordance was still protective: AOR [95 % CI]: 0.432 [0.262–0.713], p=0.001. Yet, the exclusion of patients who died of non-infectious causes did not significantly modify the results of our multivariate analysis.

Table 2 Main therapeutic means in the study groups, duration of hospital stay, and outcome. We considered that intensive care requirement for patients initially admitted to a medical department was an unfavorable outcome, suggesting inadequate antibiotic therapy

Antibiotic therapy	Group 1 n=847 (61.8 %)	Group 2 n=523 (38.2%)	p-Value
Unchanged antibiotic treatment	755 (89.1)	333 (63.7)	<0.001
Amoxicillin	264 (31.2)	0	
Amoxicillin+clavulanic acid	214 (25.2)	0	
Roxithromycin (RX)	95 (11.2)	0	
Amoxicillin+ofloxacin	94 (11.0)	0	
Amoxicillin+clavulanic acid+RX	50 (5.9)	0	
Amoxicillin+RX	17 (2.0)	0	
Levofloxacin	12 (1.4)	70 (13.4)	<0.001
Clarithromycin	0	42 (8.0)	
Ofloxacin	0	39 (7.4)	
Third-generation cephalosporins (Ceph-3)[a]	0	26 (4.9)	
Amoxicillin+clavulanic acid+FQ[b]	0	20 (3.8)	
Ceph-3+metronidazole	0	18 (3.5)	
Ceph-3+FQ[b]	0	18 (3.5)	
Other FQ[b]	0	16 (3.0)	
Ceph-3+macrolides[c]	0	7 (1.3)	
Other molecules, including combinations	0	77 (14.7)	
Tamiflu	9 (1.0)	0	
Effective antibiotic reassessment[d]			
2 courses of antibiotics	85 (10.0)	162 (30.9)	<0.001
≥3 courses of antibiotics	7 (0.8)	28 (5.3)	<0.001
Duration of hospital stay (days)	7.6±4.8	9.1±6.0	<0.001
Unfavorable outcome	46 (5.4)	52 (9.9)	0.001
ICU	11 (1.3)	15 (2.7)	
Death	35 (4.1)	37 (7.2)	
Causes of death			0.019
Infection	18 (51.5)	24 (64.8)	
Comorbid conditions	14 (40.0)	5 (13.5)	
Treatment limitations	1 (2.8)	7 (18.9)	
Others	2 (5.6)	1 (2.7)	

[a] Among ceftriaxone, cefotaxime, ceftazidime

[b] FQ=fluoroquinolone among ciprofloxacin, ofloxacin, pefloxacin, moxifloxacin, levofloxacin

[c] Among azithromycin, erythromycin, clarithromycin

[d] Antibiotic reassessment which led to an addition or a suppression of the antibiotic therapy

Discussion

Multiresistant bacterial infections are associated with high levels of treatment failure and an increase in morbidity and mortality [30–32]. For the past 15 years, a major concern in public health is the better use of antibiotic therapy to reduce as much as possible the prevalence of these MRB [24, 33, 34]. Concerning CAP, our consensus was designed to restrict RFQ and Ceph-3 use.

This study evaluated the impact of our therapeutic choice for CAP, avoiding Ceph-3 and FQ as empirical treatments, focusing on the two major outcome parameters, which are LOS and in-hospital outcome. We observed both a shorter LOS and a better outcome, as defined by the absence of ICU requirement and survival, when the antibiotic therapy was in accordance with the guideline.

Previous studies have already shown that compliance with the guideline was independently associated with several indicators of better care: a lower duration of parenteral antibiotic administration, a restriction of antibiotic use and more single courses of treatment, a shorter hospital stay, a lower cost expenditure, and, most importantly, a better outcome [13, 34].

The new information provided by our work is that reduced LOS and better inpatient outcome are obtained with a

Table 3 Risk factors associated with unfavorable outcome. Univariate analysis. A total of 12 PSI were not determined

	Favorable outcome n=1,272 (92.8 %)	Unfavorable outcome n=98 (7.2 %)	p-Value
Age (years)	65±19	78±15	<0.001
Sex ratio (M/F)	1.49	1.57	0.809
Comorbid conditions			
Cardiovascular	462 (36.3)	42 (42.8)	0.196
Chronic heart failure	55 (4.3)	11 (11.2)	0.002
Diabetes	173 (13.6)	20 (20.4)	0.062
Neurological and/or psychiatric	300 (23.5)	24 (24.5)	0.839
Pulmonary	340 (26.7)	23 (23.5)	0.481
COPD	112 (8.8)	13 (13.2)	0.139
Active smoking	173 (13.6)	3 (3.1)	0.004
Cancers/immunodepression	80 (6.3)	12 (12.2)	0.023
HIV infection	119 (9.7)	3 (3.1)	0.031
Alcoholism	98 (7.7)	5 (5.1)	0.346
Liver diseases	172 (13.5)	9 (9.2)	0.221
Chronic renal failure	98 (7.7)	12 (12.2)	0.111
Aspiration pneumonia	107 (8.4)	15 (15.3)	0.020
PSI (mean±standard deviation)	80±31	112±33	<0.001
PSI<3	413 (39.0)	7 (7.2)	<0.001
PSI 3	319 (25.3)	19 (19.6)	0.210
PSI 4	370 (29.3)	43 (44.3)	0.002
PSI 5	79 (6.2)	28 (28.9)	<0.001
Microbial data			
Positive blood culture	77 (6.0)	6 (6.1)	0.978
Polymicrobial respiratory samples	484 (38.0)	45 (45.9)	0.123
Main bacterial pathogens*			
Streptococcus pneumoniae	236 (18.5)	16 (16.3)	0.583
Legionella pneumophila	90 (7.0)	8 (8.1)	0.687
Enterobacteriaceae	54 (4.2)	6 (6.1)	0.381
Haemophilus influenzae	38 (2.9)	0	0.156
Staphylococcus aureus	21 (1.6)	5 (5.1)	0.015
Pseudomonas aeruginosa	13 (1.0)	6 (6.1)	<0.001
Atypical pathogens	39 (3.0)	2 (2.0)	0.566
Influenza virus	32 (2.5)	1 (1.0)	0.556
Concordance with guideline	801 (62.9)	46 (46.9)	0.001

*Including monomicrobial samples only, the diagnosis being based on standard isolation procedures (analysis of sputums, bronchoalveolar lavages, bronchic aspirations)

Table 4 Risk factors for unfavorable outcome in patients with community-acquired pneumonia (CAP) using a stepwise logistic regression analysis

Risk factors	p-Value	AOR [95 % CI]
P. aeruginosa infection	0.0088	4.277 [1.441–12.694]
Pneumonia Severity Index	<0.0001	1.028 [1.022–1.035]
Guideline concordance	0.0055	0.538 [0.347–0.833]

simplified antibiotic therapy compared to most international recommendations [6–8].

This shorter LOS is not explained by any change in our medical team, while our hospital structure and department did not change at all. Moreover, our database indicated that, globally, the mean LOS did not decrease from 2005 (8.5 days) to 2014 (9.6 days), even if in the DRG "cutaneous infections" it was lowered by the implementation of our internal guideline [35].

Regarding the better outcome associated with guideline concordance, this result was obtained despite comparable

levels of the PSI between groups and after comparison of the most comorbid conditions which are known to impact on LOS and outcome. Importantly, nearly all patients with immunosuppressive conditions were included (>15 % of the total population), suggesting that our results could be applicable to high-risk populations. This important result was still observed whichever the subpopulation tested: excluding non-severe cases (PSI 1 and 2), focusing on PSI 4 and 5 only, patients who benefited from at least of 2 days of antibiotic treatment, or after the exclusion of patients for whom death was not directly related to the respiratory infection.

Our consensus took into account the first main recommendation written in US guidelines, which is to implement the process of care to local conditions [6].

The first difference between our guideline and international recommendations is the rapid and systematic use of urine antigen tests for *S. pneumoniae* and *L. pneumophila*. Due to the development of resistance to antibiotics, pathogen identification and streamlining of antibiotic therapy is of great importance. This clinical practice allowed us to optimize the antibiotic therapy through simplification, specifically for very old patients [28, 29]. We think that this may explain, at least in part, our frequent use of one single course of antibiotics.

The second difference is that we did not observe the need for Ceph-3 nor FQ, as the major part of Gram-negative bacilli appeared as upper respiratory colonization in our successive evaluations [27–29]. As expected, the most common bacterial pathogen was *S. pneumoniae*, which exhibits increasing antibiotic resistance to macrolides and RFQ [26]. On the contrary, resistance to ampicillin (MIC>2 mg/L) is rare in France (<1 % of pneumococcal pneumonia) [25]. Therefore, in our clinical practice, amoxicillin is the best treatment for *Pneumococcus* infection, while macrolide is clinically equivalent to FQ for legionellosis [36–39]. In our study, roxithromycin was mainly prescribed for *Legionella* infection or when clinical and radiological findings were strongly suggestive of atypical pathogens. It was associated with one death related to severe legionellosis in an 88-year-old man with disseminated prostatic cancer and acute renal failure. Finally, MRSA in respiratory samples appeared to be very rare in the setting of CAP in our area (0.68 % in our study).

Given our results, the main question is why the observance of our simplified therapeutic guideline, compared to most international published consensus, offers good results on major markers of outcome in CAP? We know from our medical dashboard that there were no more adverse effects or secondary diagnoses such as heart failure in group 2 [40]. It might be because our guideline describes points of care other than antibiotic therapy, e.g., bacterial investigations and adequate radiologic means, which were previously evaluated [29, 35]. Accordingly, implementation of the clinical pathway for CAP has been shown to improve the outcome as compared with non-pathway patients [10, 41, 42]. An Italian before (1,443 patients) and after (1,404 patients) study showed that antibiotic therapy consistent with the guideline was associated with a significant reduction in the mortality rate compared with non-compliant therapies.

However, *P. aeruginosa* infections were still associated with unfavorable outcome, despite our recommendation for systematic bacteriological analysis and consideration for antipseudomonal therapy in case of therapeutic failure of the initial antibiotic regimen. Accordingly, risk factors for *P. aeruginosa* infection were taken into account, as 20/32 (62.5 %) of these infections benefited from specific antibiotic therapy. This result suggests the need for other indicators of *P. aeruginosa* infection to increase patient survival.

The main strength of our study is based on the use of our own medical dashboard. This data collection system allows the analysis of a cohort of patients with CAP, avoiding selection biases. Data were verified through several steps with constant medical terms which are more comprehensive and reliable than what can be obtained from administrative databases designed for other purposes.

Our study has some limitations, as it was performed in a single institution, there was no randomized treatment assignment and only in-hospital mortality was measured. Also, as our main goal was the evaluation of our empirical therapy for CAP, we did not include as concordant therapy those patients treated with Ceph-3 and/or RFQ based on microbiological results. However, when including these patients in the concordant therapy group, our results were still valid (data not shown).

Conclusion

Our simplified antibiotic therapy for community-acquired pneumonia (CAP) was associated with a shorter length of hospital stay (LOS) and a lower in-hospital mortality. If our results are confirmed in a multicenter study, these therapeutic choices might lead to a significant reduction of antibiotic pressure fighting the increase of multidrug-resistant pathogens.

Conflict of interest The authors declare no conflicts of interest.

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