

Effect of a 3-Step Critical Pathway to Reduce Duration of Intravenous Antibiotic Therapy and Length of Stay in Community-Acquired Pneumonia

A Randomized Controlled Trial

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Background: The length of hospital stay (LOS) for community-acquired pneumonia (CAP) varies considerably, even though this factor has a major impact on the cost of care. We aimed to determine whether the use of a 3-step critical pathway is safe and effective in reducing duration of intravenous antibiotic therapy and length of stay in hospitalized patients with CAP.

Methods: We randomly assigned 401 adults who required hospitalization for CAP to follow a 3-step critical pathway including early mobilization and use of objective criteria for switching to oral antibiotic therapy and for deciding on hospital discharge or usual care. The primary end point was LOS. Secondary end points were the duration of intravenous antibiotic therapy, adverse drug reactions, need for readmission, overall case-fatality rate, and patients' satisfaction.

Results: Median LOS was 3.9 days in the 3-step group and 6.0 days in the usual care group (difference, -2.1 days; 95% CI, -2.7 to -1.7; $P < .001$). Median duration of intravenous antibiotic therapy was 2.0 days in the 3-step

group and 4.0 days in the usual care group (difference, -2.0 days; 95% CI, -2.0 to -1.0; $P < .001$). More patients assigned to usual care experienced adverse drug reactions (4.5% vs 15.9% [difference, -11.4 percentage points; 95% CI, -17.2 to -5.6 percentage points; $P < .001$]). No significant differences were observed regarding subsequent readmissions, case fatality rate, and patients' satisfaction with care.

Conclusions: The use of a 3-step critical pathway was safe and effective in reducing the duration of intravenous antibiotic therapy and LOS for CAP and did not adversely affect patient outcomes. Such a strategy will help optimize the process of care of hospitalized patients with CAP, and hospital costs would be reduced.

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IN THE UNITED STATES, IT IS ESTIMATED that more than 4 000 000 people develop community-acquired pneumonia (CAP) every year.¹ Patients with CAP are primarily treated as outpatients, but patients who require hospitalization consume the greatest proportion of economic resources. Data from the United States showed that there were 1.3 million

See Invited Commentary at end of article

hospitalizations for pneumonia in 2005² and that the cost of care for patients with CAP, including both direct and indirect costs, has been estimated at more than \$40 billion. Pneumonia in Europe is esti-

mated to result in an annual expenditure of €10.1 billion³; of this amount, inpatient care accounts for €5.7 billion.

Length of hospital stay (LOS) is the most important component of the cost of CAP.^{4,5} Moreover, longer stay places patients at risk of complications such as phlebitis, pulmonary embolism, and nosocomial infection.⁶ Nevertheless, investigators have reported considerable variations in LOS for patients with CAP, suggesting that physicians do not use a uniform strategy to decide hospital discharge.⁷⁻¹⁰ The duration of intravenous (IV) antibiotic therapy is a major determinant of LOS. Therefore, switching from IV to oral therapy as soon as patients are clinically stable may help shorten LOS and reduce associated costs.¹¹⁻¹³ However, patients with CAP often remain hospitalized after be-

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coming clinically stable, and the maintenance of antibiotic IV therapy is a major limitation for discharge.¹⁴

In an era of increasing competition in medical care, institutions have embraced critical pathways as a strategy for decreasing cost and improving health care quality.^{15,16} Nevertheless, evidence from prospective controlled trials to evaluate the effects of critical pathways for CAP is scarce. We designed this randomized trial to test the hypothesis that the use of a 3-step critical pathway would be as safe as, and more effective than, usual care in reducing the duration of IV antibiotic therapy and LOS in hospitalized patients with CAP. The primary end point of the trial was LOS. Secondary end points were the duration of IV antibiotic therapy, adverse drug reactions, need for readmission, overall case-fatality rate, and patients' satisfaction.

METHODS

STUDY DESIGN AND SETTING

This prospective, randomized trial was conducted at 2 tertiary hospitals in Barcelona, Spain, between May 1, 2005, and December 31, 2007: the Bellvitge Institute for Biomedical Research (IDIBELL)–Hospital Universitari de Bellvitge, a 900-bed university public hospital, and the SCIAS–Hospital de Barcelona, a 300-bed private hospital. The study was approved by the ethics committees of both institutions.

PATIENT ELIGIBILITY AND RECRUITMENT PROCESS

All immunocompetent patients 18 years or older who were diagnosed as having CAP in the emergency department were screened for eligibility. Patients with neutropenia ($<500/\mu\text{L}$) or human immunodeficiency virus infection or who had undergone transplantation or using immunosuppressive drugs were excluded. Community-acquired pneumonia was defined as the presence of an infiltrate on chest radiograph plus 1 or more of the following: fever (temperature, $\geq 38.0^\circ\text{C}$) or hypothermia ($<35.0^\circ\text{C}$), new cough with or without sputum production, pleuritic chest pain, dyspnea, and altered breath sounds on auscultation.

Patients with CAP were stratified into risk classes according to the Pneumonia Severity Index.¹⁷ All patients in risk classes IV and V were considered for randomization. Patients in risk classes I, II, and III were also considered for randomization if they met 1 or more of the following: respiratory failure ($\text{PaO}_2 < 60$ mm Hg, saturation $\leq 90\%$ using pulse oximetry, or both), unstable vital signs (temperature $> 37.8^\circ\text{C}$, heart rate $> 100/\text{min}$, systolic blood pressure < 90 mm Hg), lack of response to previous antibiotic therapy (≥ 48 hours), metastatic infection, or concomitant unstable comorbid conditions necessitating hospitalization for treatment. Patients were excluded if they met 2 or more of the following: intensive care unit admission from the emergency department, imminent death, shock, complicated pleural effusion (empyema or large effusion), pregnancy, aspiration pneumonia, and severe social problems (eg, homeless, drug abuse, severe mental disorders).

RANDOMIZATION

An epidemiologist (X.C.) generated the random allocation sequence. Randomization was performed in computer-generated blocks of 10, with the randomization code kept by

the clinical epidemiologist in a sealed envelope. The randomization was stratified according to hospital. In the emergency department, patients who met the study criteria and provided written informed consent were randomized by the infectious disease consultant, who opened the sealed, sequentially numbered, opaque envelopes.

Patients were enrolled and randomly assigned by investigators to follow a 3-step critical pathway or to receive usual care. To avoid potential biases due to the habitual practices of individual physicians, patients' attending physicians were divided into 2 groups: physicians who only had to treat patients randomly assigned to follow the 3-step critical pathway and physicians who only had to treat patients assigned to receive usual care. An epidemiologist (X.C.), who was blinded to the identity of the physicians, created 2 groups of 5 physicians with similar LOS. The groups were formed on the basis of the median LOS of patients with CAP attended by these physicians during the 2 years prior to the present study (median, 7.5 days).

The 3-steps of the critical pathway were (1) early mobilization of patients; (2) use of objective criteria for switching to oral antibiotic therapy; and (3) use of predefined criteria for deciding on hospital discharge. Early mobilization was defined as movement out of bed with a change from the horizontal to the upright position for at least 20 minutes during the first 24 hours of hospitalization, with progressive movement each subsequent day during hospitalization, as described elsewhere.¹⁸ Patients were switched from IV to oral therapy when they experienced clinical improvement and met the following objective criteria: ability to maintain oral intake; stable vital signs (considered as temperature $\leq 37.8^\circ\text{C}$, respiratory rate ≤ 24 breaths/min, systolic blood pressure ≥ 90 mm Hg without vasopressor support for at least 8 hours); and absence of exacerbated major comorbidities (ie, heart failure, chronic obstructive pulmonary disease) and/or septic metastases. Predefined criteria for hospital discharge were meeting criteria for switching to oral antibiotic, baseline mental status, and adequate oxygenation on room air ($\text{PaO}_2 \geq 60$ mm Hg or pulse oximetry $\geq 90\%$). For patients with chronic hypoxemia or receiving chronic oxygen therapy, PaO_2 or pulse oximetry measurement had to be similar to their baseline values. Criteria for switching to oral antibiotic therapy and hospital discharge could be met simultaneously or sequentially.

A printed checklist detailing the 3-step pathway was added to the medical chart of patients assigned to this study arm to remind attending physicians of the necessity of early mobilization and also to remind them of the criteria for switching to oral antibiotic therapy and for deciding on hospital discharge. Patients randomly assigned to receive usual care were treated according to the standard practices of individual attending physicians.

STUDY END POINTS

The primary end point of the trial was LOS. Secondary end points were the duration of IV antibiotic therapy, adverse drug reactions, need for hospital readmission in the 30 days after randomization, death from any cause in the 30 days after randomization, and patients' satisfaction with the care received for pneumonia.

ANTIBIOTIC THERAPY, FOLLOW-UP, AND OUTCOMES ASSESSMENT

Empirical antibiotic therapy was administered in the emergency department in accordance with the hospital's guidelines (which recommend the administration of a β -lactam agent (ceftriaxone sodium or amoxicillin sodium–clavulanate potassium) with or without a macrolide or fluoroquinolone. Com-

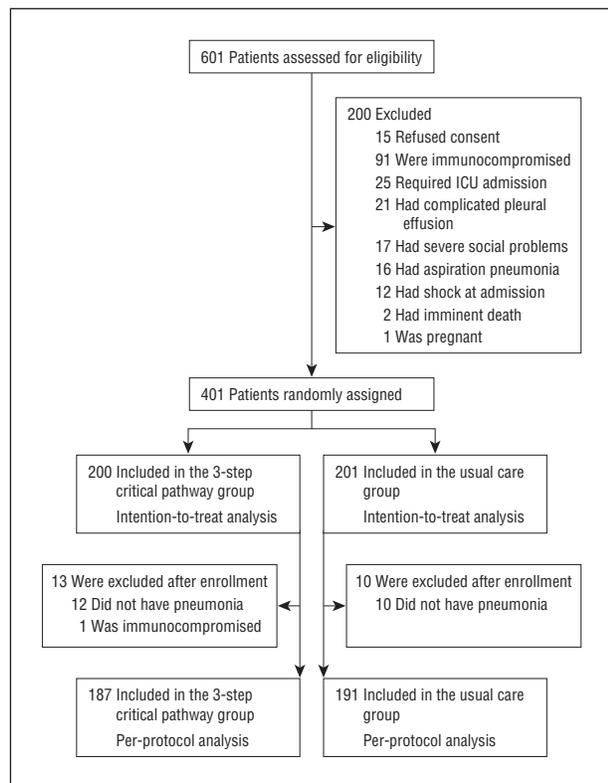


Figure. Flowchart of the trial. ICU indicates intensive care unit.

bination therapy was recommended for patients with severe CAP.¹ Levofloxacin monotherapy was indicated for *Legionella pneumoniae* and for selected cases.

Patients were seen daily during their hospital stay by attending physicians and by at least one of the investigators. The investigators assessed and recorded all the primary and secondary outcome measures. Length of hospital stay was measured in days and was calculated as the time from the admission date to the date of discharge. Duration of IV antibiotic therapy was also measured in days and was calculated as the time from the initial dose of antibiotics in the emergency department to the last dose of the IV antibiotics. Patients were followed-up at the outpatient clinic 30 days after hospital discharge. All assessments were made using a standard protocol with a checklist of items. The investigators recorded readmission for any reason within 30 days after pneumonia diagnosis. This information was obtained from a specific search for hospital readmission in the admission databases of both hospitals and checked by asking patients at the final outpatient 30-day visit. Overall case fatality rate was defined as death due to any cause less than 30 days after hospitalization.

Patients' satisfaction with their overall care for pneumonia was evaluated at hospital discharge in response to the question "How would you rate your overall care for this episode of pneumonia?" as previously reported.¹⁹ Responses were recorded on a scale of 1 to 5, from "very unsatisfactory" to "very satisfactory." Patients were considered satisfied if the response recorded was 4 or 5.

MICROBIOLOGICAL ANALYSIS

Samples obtained per protocol consisted of 2 sets of blood cultures, a sputum sample when available, urine for detection of antigens, and paired acute and convalescent serum samples.²⁰ *Streptococcus pneumoniae* antigen in urine was detected using

a rapid immunochromatographic assay (BinaxNOW; Binax Inc). *Legionella pneumophila* serogroup 1 antigen in urine was detected using a commercial immunoenzymatic method (enzyme-linked immunosorbent assay [Bartels ELISA]; Trinity Biotech). Serological studies were performed by standard methods to determine antibodies against atypical agents (*Mycoplasma pneumoniae*, *Chlamydomphila psittaci*, *Chlamydomphila pneumoniae*, and *Coxiella burnetii*).

STATISTICAL ANALYSIS

We estimated that we would need a total sample size of 380 patients to achieve 82% power at a 5% significance level using paired *t* tests to detect a 1.5-day difference in LOS between 2 treatment groups. After assuming a priori that up to 5% of patients would not be evaluable, we set the sample size target for randomization at 200 patients per treatment group.

To assess differences in the frequency of outcomes in the 2 groups, descriptive statistics were calculated for all variables. Categorical variables were compared in the 2 groups using the χ^2 or Fisher exact test, overall and for each hospital, and continuous variables were compared using the Mann-Whitney test. Percentage differences of each outcome and mean differences between the 2 groups, with corresponding 95% confidence intervals, were also computed and presented. Data for the primary and secondary end points were analyzed on an intention-to-treat and per protocol basis. The intention-to-treat analysis included all randomly assigned patients. Because both analyses produced virtually the same results, only the intention-to-treat analysis is presented in detail. Statistical significance was established at the .05 α value.

RESULTS

We assessed 601 consecutive patients for eligibility, of whom 200 were excluded (**Figure**). A total of 401 patients were randomly assigned and included in an intention-to-treat analysis for the primary and secondary end points. Of these, 200 were assigned to follow the 3-step critical pathway and 201 received usual care. The baseline characteristics of the patients in the 2 treatment groups were similar (**Table 1**).

A cause was established in 111 of 187 patients (59.4%) in the 3-step critical pathway group and in 109 of 191 patients (57.1%) in the usual care group who had pneumonia. The distribution of causative organisms did not differ between groups. *Streptococcus pneumoniae* (85 patients in the 3-step critical pathway group vs 79 in the usual care group) and *L pneumophila* (13 vs 16 respectively) were the most frequently isolated pathogens, followed by *Haemophilus influenzae* (10 vs 10) and by atypical agents (3 vs 4).

No differences were found regarding the median (range) time to institution of antibiotic therapy between groups (3.3 [1-13] days vs 4.0 [1-20] days; *P* = .45). Most patients were initially treated with combination antibiotic therapy (112 vs 111 patients). The regimens most frequently prescribed were β -lactam plus levofloxacin (65 vs 61 patients) and β -lactam plus macrolide (47 vs 49 patients). A single antimicrobial agent was given to 88 patients in the 3-step group and 90 patients in the usual care group. The antimicrobials most frequently administered as monotherapy were ceftriaxone (39 vs 32 patients), amoxicillin-clavulanate (18 vs 20 patients), and levofloxacin (24 vs 34 patients).

Table 2 details outcomes for study patients. In the intention-to-treat analysis, the median LOS was 3.9 days in the 3-step group vs 6.0 days in the usual care group (difference, -2.1 days; 95% CI, -2.7 to -1.7; $P < .001$). The median duration of IV antibiotic therapy was 2.0 days in the 3-step group and 4.0 days in the usual care group (difference, -2.0 days; 95% CI, -2.0 to -1.0; $P < .001$). Equivalent results regarding the LOS and the median duration of IV antibiotic therapy were obtained in the per-protocol analysis and when analyzing only the cases microbiologically documented.

Early mobilization was not performed in 8 patients in the 3-step critical pathway group. Six of these patients felt too ill to be mobilized, and 2 had severely altered mental status. Adverse drug reactions, mainly phlebitis, were more frequent in the usual care group (Table 2). In the intention-to-treat analysis, there were no differences between groups regarding the development of in-hospital complications and overall mortality. In the per-protocol analysis, the results were equivalent. Causes of death were respiratory failure (3 patients) and multiorgan failure (1 patient) in the 3-step critical pathway group and cancer (1 patient) and sudden death (1 patient) in the usual care group.

As detailed in Table 2, the numbers of patients required readmission (<30 days) were similar in the 2 groups. In the 3-step critical pathway group, the reasons for readmission were as follows: exacerbation of chronic obstructive pulmonary disease (7 patients), cancer (2 patients), empyema (2 patients), acute asthma (2 patients), cerebrovascular disease (1 patient), retinal detachment (1 patient), cholecystitis (1 patient), uncomplicated pleural effusion (1 patient), and pneumonia (1 patient). In the usual care group the reasons for subsequent hospitalization were as follows: exacerbation of chronic obstructive pulmonary disease (5 patients), exacerbation of cardiac failure (3 patients), empyema (1 patient), ascites (1 patient), hepatic encephalopathy (1 patient), seizures (1 patient), dysphagia (1 patient), pneumonia (1 patient), and abdominal wall hernia (1 patient).

For the analysis of patients' satisfaction, data were available for 186 of 200 patients in the 3-step critical pathway group and for 174 of 201 patients in the usual care group. No differences were found in satisfaction between groups (4 or 5 points of the scale): 3-step critical pathway group, 176 of 186 (94.6%), vs usual care group, 164 of 174 (94.3%); absolute difference, 1.4 percentage points (95% CI, -2.7 to 5.4 percentage points) ($P = .60$).

COMMENT

In this randomized trial, we found a 3-step critical pathway including early mobilization and use of objective criteria for switching to oral antibiotic therapy and for deciding on hospital discharge to be safe and effective in reducing duration of IV antibiotic therapy and LOS compared with usual care.

Controlled clinical trials to evaluate the efficacy of interventions for decreasing the duration of IV therapy and LOS for patients hospitalized with CAP are scarce, and those published have produced mixed results. Some stud-

Table 1. Characteristics of Patients in the 3-Step Critical Pathway and Usual Care Groups

Characteristic	3-Step Critical Pathway Group (n = 200)	Usual Care Group (n = 201)
Sex, No. (%)		
Male	132 (66.0)	129 (64.2)
Female	68 (34.0)	72 (35.8)
Hospital, No. (%)		
IDIBELL-Hospital Universitari de Bellvitge	130 (65.0)	131 (65.2)
SCIAS-Hospital de Barcelona	70 (35.0)	70 (34.8)
Age, mean (SD), y	71.5 (14.0)	69.7 (15.1)
Age group, y, No. (%)		
18-49	19 (9.5)	20 (10.0)
50-69	43 (21.5)	63 (31.3)
70-97	138 (69.0)	118 (58.7)
Alcohol consumption > 80 g/d, No. (%) ^a	28 (14.8)	40 (20.6)
Tobacco smoking, No. (%) ^b	38 (20.0)	48 (24.6)
Influenza vaccine ^c	113 (62.4)	102 (55.4)
Pneumococcal vaccine, 5 y ^d	36 (20.6)	48 (27.1)
Comorbid conditions, No. (%)	166 (83.0)	169 (84.1)
Chronic obstructive pulmonary disease	44 (22.0)	48 (23.9)
Chronic heart disease	54 (27.0)	56 (27.9)
Diabetes mellitus	54 (27.0)	52 (25.9)
Chronic liver disease	9 (4.5)	14 (7.0)
Chronic renal disease	16 (8.0)	22 (10.9)
Oxygen saturation with room air, mean (SD), % ^e	90.6 (6.1)	90.8 (5.4)
Multilobar pneumonia, No. (%)	50 (25.0)	46 (22.9)
Severity risk class, No. (%)		
I, II, III	77 (38.5)	76 (37.8)
IV	88 (44.0)	92 (45.8)
V	35 (17.5)	33 (16.4)
Pneumonia severity index, mean (SD), score	100.5 (32.5)	101.1 (31.5)

Abbreviations: IDIBELL, Bellvitge Institute for Biomedical Research.

^aNo data were available for 11 patients in the 3-step critical pathway group and 7 patients in the usual care group.

^bNo data were available for 10 patients in the 3-step critical pathway group and 6 patients in the usual care group.

^cNo data were available for 19 patients in the 3-step critical pathway group and 17 patients in the usual care group.

^dNo data were available for 25 patients in the 3-step critical pathway group and 24 patients in the usual care group.

^eNot applicable to 19 patients in the 3-step critical pathway group and 17 in the usual care group.

ies support their efficacy,^{13,18,21} but others do not.^{22,23} Our randomized trial differs from previous investigations in that the intervention arm consisted in the application of an easy-to-perform 3-step critical pathway, with early mobilization as the first step.^{14,22-24} The mechanism by which early mobilization contributes to reducing LOS is unknown. It has been hypothesized that in mobilization from horizontal to upright position there may be improvement in aeration and/or blood flow redistribution with optimized drug delivery to the site of infection, reduced risk of aspiration, and maintenance of functional health status.¹⁸

The second step of our critical pathway comprised the use of objective and simple bedside criteria for the early switch from IV to oral antibiotics. Although the duration of IV treatment is a key determinant of LOS,

Table 2. Outcomes for Study Patients by Treatment Group

Event	3-Step Critical Pathway Group (n = 200)	Usual Care Group (n = 201)	Difference (95% CI) ^a	P Value ^b
Primary end point: LOS, median (IQR), d				
Overall	3.9 (2.79 to 5.75)	6.0 (4.75 to 8.83)	-2.1 (-2.7 to -1.7)	<.001
IDIBELL–Hospital Universitari de Bellvitge	4.0 (2.83 to 5.75)	6.0 (4.62 to 8.88)	-2.0 (-2.7 to -1.3)	<.001
SCIAS–Hospital de Barcelona	3.7 (2.71 to 5.67)	6.3 (4.87 to 8.71)	-2.6 (-3.2 to -1.7)	<.001
Secondary end points				
Length of intravenous antibiotic therapy, median (IQR), d	2.0 (2.0 to 3.0)	4.0 (2.0 to 6.0)	-2.0 (-2.0 to -1.0)	<.001
Adverse drug reactions, No. (%)	9 (4.5)	32 (15.9)	-11.4 (-17.2 to -5.6)	<.001
Phlebitis	8 (4.0)	21 (10.4)	-6.4 (-11.5 to -1.4)	.02
Skin eruption	0	2 (1.0)	-1.0 (-2.4 to 0.4)	.50
Vomiting/diarrhea	0	4 (2.0)	-2.0 (-3.9 to -0.1)	.12
Allergy	1 (0.5)	1 (0.5)	0 (-1.4 to 1.4)	>.99
Transaminitis	0	3 (1.5)	-1.5 (-3.2 to 0.2)	.25
Medical complications, No. (%)	40 (20.0)	49 (24.4)	-4.4 (-12.6 to 3.8)	.34
Empyema	3 (1.5)	6 (3.0)	-1.5 (-4.4 to 1.4)	.50
Cardiac complication ^c	8 (4.0)	16 (8.0)	-4.0 (-8.6 to 0.7)	.14
Respiratory failure	15 (7.5)	8 (4.0)	3.5 (-1.0 to 8.1)	.14
Acute confusion	7 (3.5)	8 (4.0)	-0.5 (-4.2 to 3.2)	>.99
Renal failure	7 (3.5)	8 (4.0)	-0.5 (-4.2 to 3.2)	>.99
Nosocomial infection	2 (1.0)	3 (1.5)	-0.5 (-2.7 to 1.7)	>.99
Severe hyperglycemia	3 (1.5)	9 (4.5)	-3.0 (-6.3 to 0.3)	.14
Shock	2 (1.0)	3 (1.5)	-0.5 (-2.7 to 1.7)	>.99
Subsequent hospital admission (<30 d), No. (%) ^d	18 (9.1)	15 (7.5)	1.6 (-3.8 to 7.1)	.59
Overall case-fatality rate (<30 d), No. (%)	4 (2.0)	2 (1.0)	1.0 (-1.4 to 3.4)	.45

Abbreviations: IDIBELL, Bellvitge Institute for Biomedical Research; IQR, interquartile range; LOS, length of hospital stay.

^aValues are percentage points.

^bCategorical variables were compared using the Fisher exact test and continuous variable using the Mann-Whitney test.

^cCardiac complications included 1 or more of the following: heart failure (4 vs 6), arrhythmia (5 vs 11), and angina pectoris (0 vs 1).

^dExcluding 4 deaths in the 3-step critical pathway group and 2 in the usual care group.

strategies of early switching to oral antibiotic have mainly been evaluated in observational studies^{11,12,25} but less frequently in randomized trials.^{13,26,27} Finally, the third step of our intervention arm was based on the use of objective criteria for clinical stability and to decide appropriateness for hospital discharge. In this regard, other investigators have shown that once stability is achieved in patients with CAP, the risk of serious clinical deterioration is 1% or less, even in the sickest subgroup of patients.²⁸

In recent years, there has been concern that efforts to reduce LOS would increase the proportion of patients being discharged “sicker and quicker,” who may thus experience an increased risk of adverse outcomes.^{29,30} In our study, the 2-day decrease in LOS in the 3-step group was not significantly associated with a greater number of hospital readmissions or a higher overall mortality compared with the usual care group. It should be noted, however, that patients receiving usual care were more likely to experience adverse drug reactions, mainly phlebitis, probably related to the longer duration of IV antibiotic therapy in this group.

In an era of cost containment and resource constraints in health care systems, cost-effective health care delivery is of paramount importance.³¹ The economic burden associated with CAP remains substantial, and LOS is the most important driver of the cost in hospitalized patients.³² In a recent study carried out in the United States, it has been estimated that eliminating a day during the course of a CAP admission is potentially worth

\$2273 to \$2373 in economic benefits.³³ Therefore, our finding that the application of a 3-step critical pathway reduced the LOS by 2 days compared with usual care may have significant economic implications.

Our study has several limitations. First, outcomes were assessed by investigators who were aware of patient treatment assignments. Nevertheless, the LOS and the duration of IV antibiotic therapy were ascertained using objective data. Second, it is possible that practices among physicians treating patients in the usual care group may have been influenced by interactions with physicians applying the 3-step pathway during the course of the study. However, the influence of these interactions would probably have reduced the LOS in the control group rather than in the intervention arm. Third, our study was not powered to detect a survival difference. Fourth, the trial was not designed to evaluate the effectiveness of the separate components of the 3-step critical pathway. Finally, since about a third of the hospitalized patients with CAP were excluded, our conclusions apply only to the selected population analyzed.

In conclusion, in a population of immunocompetent adults with CAP requiring hospitalization, the use of a 3-step critical pathway was safe and effective in reducing the duration of IV antibiotic therapy and LOS and did not adversely affect patient outcomes.

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INVITED COMMENTARY

Putting a Critical Pathway Into Practice

The Devil Is in the Implementation Details

Imagine if, for the cost of a single sheet of paper and the effort required to place it in the patient's medical chart, you could reduce length of stay by 2 days and save up to \$4600 per patient yet have no impact on readmission rate, 30-day mortality, or patient satisfaction. One might think a deal with the devil had been struck, as public and private insurers, health care systems, hospitals, and individual health care providers would likely pay a fair amount for such an intervention.

IMPLEMENTATION OF A 3-STEP CRITICAL PATHWAY

Amazingly, in this issue of the *Archives*, Carratalà et al¹ describe such a high-yield, low-risk, low-cost intervention. The authors report the impact of a simple, evidence-based, 3-step critical pathway for patients hospitalized with community-acquired pneumonia (CAP). They enrolled 401 immunocompetent patients at 2 Spanish hospitals (1 public and 1 private) who were admitted with CAP and randomized them to the critical pathway or usual care. The critical pathway included 3 components: (1) early mobilization, (2) use of objective criteria for switching to oral antibiotics, and (3) use of evidence-based criteria for appropriate hospital discharge.

The results are impressive. The authors report a reduction in the median length of stay (-2.1 days) and median duration of intravenous antibiotics (-2.0 days) and fewer adverse events (-11.4%) in the pathway group. There were no differences in 30-day readmission or 30-day mortality, and patients were equally satisfied with the critical pathway and usual care.

The patients were randomized, the sample size was large, and the results seem valid. Are these results generalizable? Should health care systems and providers implement this care pathway tomorrow? The answer is yes, but as with most interventions that require changing physician behavior, the devil is in the implementation details.

The authors report that patients were randomized "to follow a 3-step critical pathway" and were by protocol mobilized early, switched to oral antibiotic therapy, and discharged according to the specified criteria. The reported strategy involved selecting a limited number of physicians for the intervention arm (who remained "un-

blinded") and placing a "printed checklist detailing the 3-step pathway" in the medical chart reminding the physicians of the intervention. Unfortunately, only failure to perform early mobilization was reported by the authors (in 8 of the 200 patients). Therefore, we must assume that all of the patients in the intervention group were switched to oral therapy and discharged according to the 3-step pathway. Was physician awareness of the intervention and placement of a single piece of paper in the medical record enough to achieve 100% adherence to the pathway?

The research exploring optimal means of introducing evidence-based medicine and guidelines into daily practice (including implementation of care pathways or protocols) would suggest this is highly unlikely; changing physician behavior is challenging.^{2,3} In a systematic review that evaluated the impact of printed educational materials alone (eg, a form placed in the medical chart) on health care providers' practices, the benefits were modest compared with no intervention, only increasing adherence to recommended practices by 4.3% to 13.6%.⁴ Even when harnessing the power of electronic health records and active decision support, the impact on physician behavior remains small. A systematic review of on-screen point-of-care computer reminders revealed a median improvement in process adherence of only 4.2%.⁵ Even when physicians are aware they are being audited and receive feedback, as they likely were in this trial, the impact is only small to moderate.⁶

ACHIEVING ADHERENCE

If there was 100% adherence to this critical pathway, how was this achieved? How might other institutions achieve these outstanding results? It may have been a consequence of intensive investigator involvement as part of the randomized trial. According to the protocol, patients were seen daily by at least one of the investigators to assess and record outcomes; presumably they could ensure adherence and compliance with the checklist. Whether this could easily be replicated in other hospitals and the cost of this intervention are not clear. Given the established barriers to changing physician practice, without knowledge of the necessary steps in implementation, the generalizability of the findings are limited.^{2,3}