Time to Clinical Stability in Patients Hospitalized With Community-Acquired Pneumonia

Implications for Practice Guidelines

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Context.—Many groups have developed guidelines to shorten hospital length of stay in pneumonia in order to decrease costs, but the length of time until a patient hospitalized with pneumonia becomes clinically stable has not been established.

Objective.—To describe the time to resolution of abnormalities in vital signs, ability to eat, and mental status in patients with community-acquired pneumonia and assess clinical outcomes after achieving stability.

Design.—Prospective, multicenter, observational cohort study.

Setting.—Three university and 1 community teaching hospital in Boston, Mass, Pittsburgh, Pa, and Halifax, Nova Scotia.

Patients.—Six hundred eighty-six adults hospitalized with community-acquired pneumonia.

Main Outcome Measures.—Time to resolution of vital signs, ability to eat, mental status, hospital length of stay, and admission to an intensive care, coronary care, or telemetry unit.

Results.—The median time to stability was 2 days for heart rate (≤100 beats/min) and systolic blood pressure (≥90 mm Hg), and 3 days for respiratory rate (≤24 breaths/min), oxygen saturation (≥90%), and temperature (≤37.2°C [99°F]). The median time to overall clinical stability was 3 days for the most lenient definition of stability and 7 days for the most conservative definition. Patients with more severe cases of pneumonia at presentation took longer to reach stability. Once stability was achieved, clinical deterioration requiring intensive care, coronary care, or telemetry monitoring occurred in 1% of cases or fewer. Between 65% to 86% of patients stayed in the hospital more than 1 day after reaching stability, and fewer than 29% to 46% were converted to oral antibiotics within 1 day of stability, depending on the definition of stability.

Conclusions.—Our estimates of time to stability in pneumonia and explicit criteria for defining stability can provide an evidence-based estimate of optimal length of stay, and outline a clinically sensible approach to improving the efficiency of inpatient management.

JAMA. 1998;279:1452-1457

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An earlier version of this work was presented at the Society of General Internal Medicine meeting in Washington, DC, May 2, 1997.

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COMMUNITY-ACQUIRED pneumonia (CAP) is one of the most common inpatient medical conditions, accounting for more than 600 000 hospital admissions in the United States each year.[1] Substantial variation in the length of hospital stay for CAP has been well documented within different regions, different hospitals, and even within hospitals.[2-6] These differences in length of stay persist even after adjusting for disease severity, comorbid conditions, and hospital characteristics, which suggests that clinical uncertainty and/or differences in physician practice style may be important and mutable determinants of management.[6-8] In addition, a physician survey of the discharge decision in CAP indicated that 22% of pneumonia inpatients remained in the hospital beyond reaching medical stability, indicating sizable opportunity for improving efficiency.[9] For these reasons, providers and payers have been aggressively developing and implementing practice guidelines and critical pathways to reduce length of stay in pneumonia to decrease the cost of inpatient care.[10]

However, these guidelines are often criticized for being evidence-free because length of stay targets offered by hospitals, managed care plans, and utilization management firms are often based more on comparisons between institutions (benchmarking) or group consensus than on epidemiological data. Unfortunately, there are no studies on the time course of recovery in pneumonia that provide sufficient clinical details to help define an evidence-based estimate of optimal length of stay. In particular, not much is known about how long it takes a patient hospitalized with pneumonia to become medically stable.

While explicit definitions of clinical stability are hard to find, most textbooks and guidelines base the concept of stability on normalization of heart rate (HR), systolic blood pressure (SBP), respiratory rate (RR), temperature, oxygenation status, ability to eat, and mental status.[11,12] These clinical features have also been identified as key elements in physicians' decisions about appropriateness for discharge.[9] Therefore, to help facilitate a more evidenced-based approach to the management of CAP, we sought to answer 3 questions: (1) What is the time course of resolution of vital signs, ability to eat, and mental status abnormalities in patients hospitalized with pneumonia? (2) What is the risk of major adverse outcomes once vital sign stability has been achieved? (3) What are the potential opportunities to safely shorten length of stay?

METHODS

Study Sites

This study was part of the Pneumonia Patient Outcomes Research Team (PORT), a prospective, multicenter, observational study of outcomes in hospitalized and ambulatory patients with CAP. Complete details about the Pneumonia PORT study have been described previously.[13,14] The participating inpatient sites (and number of patients enrolled) were the University of Pittsburgh Medical Center (n=217) and St Francis Medical Center (n=59), both in Pittsburgh, Pa; the Massachusetts General Hospital (n=246), in Boston; and the Victoria General Hospital (n=164), in Halifax, Nova Scotia. The study was approved by the institutional review boards of all participating institutions.

Study Population

The Pneumonia PORT study inclusion criteria were (1) age 18 years or older, (2) symptoms suggestive of acute pneumonia, and (3) radiographic evidence of pneumonia. Patients positive for the human immunodeficiency virus or who had been hospitalized within 10 days were excluded. Overall, 2287 of the 4002 eligible ambulatory and hospitalized patients (57%) consented to participate. Enrolled patients were younger (mean age 56 vs 61 years) and were more often classified as low risk for short-term mortality (69% vs 58%) than eligible, nonenrolled patients.

As part of a substudy on all hospitalized patients enrolled in the Pneumonia PORT, detailed, daily inpatient data were collected during 2 consecutive sampling periods. During period 1 (October 15, 1991, through May 14, 1993), chart review was done on consecutive low-risk patients (<4% predicted risk of death). During period 2 (May 15, 1993, through March 31, 1994), chart review was done on all consecutive hospitalized patients regardless of mortality risk. This strategy found 686 patients who were discharged from the hospital from the overall PORT cohort of 1343 patients hospitalized with pneumonia. Because we oversampled low-risk patients during period 1, the 686 patients in the detailed daily assessment cohort were younger (mean age, 61 vs 74 years) and had lower predicted 30-day mortality rates (2% vs 6%) than patients in the overall PORT study who did not have daily chart review. During this substudy, 84% of eligible patients agreed to participate (73% during period 1, which involved more detailed patient interviews, and 94% during period 2). The mortality rates for all inpatients enrolled in the Pneumonia PORT study during periods 1 and 2 (prior to exclusion of high-risk cases in period 1) were the same (7% vs 6%). There were no differences in the mortality rates for patients entered in the 2 sampling periods when we stratified by admission-mortality risk class as defined by the pneumonia severity index ([PSI], a multivariable logistic model of short-term mortality further described below).

Baseline Data, Daily Measurements, and Definitions of Stability

Baseline information on sociodemographic characteristics, initial pneumonia severity, comorbid conditions, vital signs, mental status, ability to eat, physical examination findings, laboratory results, and chest radiograph findings was collected on admission. Pneumonia severity was assessed using the PSI, a well-validated, disease-severity classification based on age, sex, nursing home residence, 5 comorbid illnesses, vital signs on admission, mental status, 7 laboratory values, and the findings on chest x-ray films from presentation.[14] Class I patients have the least severe disease; class V patients, the most severe disease.

The highest temperature, HR, and RR, and lowest SBP, oxygen saturation, and Pa_{O_2} of each hospital day were abstracted from the medical chart. The patient's mental status and ability to eat each day was also recorded. The time to resolution of individual vital signs and clinical status abnormalities was defined as the first day that the vital sign or clinical variable was stable. A variable was considered stable if all measurements in the 24-hour period met stability criteria—a convention used by other investigators.[15,16] Stable values for vital signs were selected prior to analysis based on the literature and common clinical practice. The stability cut point for HR was at least 100 beats/min; SBP, more than 90 mm Hg; and RR, 24 breaths/min or less. Oxygenation was considered stable if the oxygen saturation was 90% or greater or the Pa_{O_2} was 60 mm Hg or greater and a patient was not receiving mechanical ventilation or supplemental oxygen by face mask. Since no consensus criteria exist for stable temperature, RR, and oxygen saturation, we examined a variety of cut points. Because data reflect usual care, room air oxygen saturation was not available on all days for all patients. The time to overall stability was defined as the first day all 5 vital signs and eating and mental status were stable.

Clinical Outcomes

We considered admission to an intensive care unit (ICU), coronary care unit (CCU), or telemetry monitoring unit (TMU) as an indicator of serious clinical instability. All admissions and transfers to an ICU, CCU, or TMU were counted as special care unit (SCU) admissions. For the few patients who had more than 1 SCU admission, only the first episode was counted. Analyses that focused on SCU admissions solely for respiratory failure, hemodynamic compromise, and shock yielded results similar to those for all causes, which we present here. Length of hospital stay was defined as the date of discharge minus the date of admission. Microbiologic etiology was assigned according to a previously described classification based on results of sputum Gram stain, sputum culture, blood culture, pleural fluid culture, and serologic studies.[17] No microbiologic testing was performed in 5% of cases. Data on antibiotic use and route of administration were collected by chart review.

Statistical Analyses

Means and SDs are presented for normal data and medians with interquartile ranges (IQRs) for nonnormal data. We used the Kaplan-Meier product-limit method (with exact calculation of ties) to characterize the time to individual vital sign stability, overall stability, and first SCU admission.[18,19] Differences among strata of PSI class were examined using log-rank tests.[19] Patients were censored at the point of the last recorded value. Those discharged prior to a particular variable stabilizing were censored as not stable. The day of admission was counted as day 1. All analyses used 2-tailed test significance levels of $P<.05$ and were conducted with SAS statistical software (SAS Institute, Cary, NC). Analyses of outcomes for patients enrolled in the 2 sampling periods yielded similar findings after controlling for differences in initial disease severity (PSI class), so we present the data for the entire cohort.

RESULTS

Patient Characteristics

Clinical features of the study subjects are summarized in Table 1. The mean patient age was 58 years (range, 18-101 years). Half (352) of the sample (N=686) were women. Three quarters of patients (511) had 1 or more major comorbid illness. Twenty-nine percent of patients (198) were classified as moderate- (class IV) or high-risk cases (class V). A definitive microbiologic etiology was determined for only 27% of patients overall (187), including 57 (8%) with *Streptococcus pneumoniae*, 43 (6%) with *Haemophilus influenzae*, 26 (4%) with multiple organisms, 21 (3%) with aerobic

Table 1.—Characteristics of 686 Patients Hospitalized With Community-Acquired Pneumonia

Characteristics	No. (%)
Age, y	
18-44	203 (30)
45-64	182 (26)
≥65	301 (44)
Female	352 (51)
White	570 (83)
Type of insurance	
Medicare or private	416 (61)
Medicaid	76 (11)
Canadian medical insurance	155 (23)
Uninsured	35 (5)
Married	295 (43)
Education greater than high school	260 (38)
Admitted from nursing home	51 (7)
Comorbidities on presentation	
Chronic obstructive pulmonary disease	143 (21)
Coronary artery disease	133 (19)
Diabetes mellitus	91 (13)
Congestive heart failure	78 (11)
Asthma	64 (9)
Renal insufficiency	56 (8)
Active cancer	36 (5)
Severity of illness on admission*	
Risk class I	150 (22)
Risk class II	186 (27)
Risk class III	152 (22)
Risk class IV	142 (21)
Risk class V	56 (8)

*Severity of illness was assessed using the Pneumonia Severity Index.[14] Class I patients have the lowest severity and mortality risk; class V, the highest.

Table 2.—Time to Stability of Individual Vital Sign and Clinical Status Abnormalities*

Criterion for Stability	Unstable on Day 1, No. (%)	Time to Stability	
		Median, d	Interquartile Range, d
Systolic blood pressure ≥90 mm Hg†	50 (7)	2	2-3
Heart rate ≤100 beats/min†	385 (56)	2	2-3
Respiratory rate, breaths/min†			
≤24	337 (49)	3	2-4
≤22	489 (71)	3	2-6
≤20	537 (78)	4	3-7
Temperature, °C (°F)‡			
≤38.3 (101)	314 (46)	2	2-3
≤37.8 (100)	432 (63)	3	2-4
≤37.2 (99)	550 (80)	3	2-6
Oxygen saturation, %§			
≥90	142 (23)	3	2-6
≥92	188 (31)	3	2-6
≥94	237 (39)	4	2-8
Ability to eat†‖	73 (11)	2	2-8
Mental status¶	56 (8)	3	2-4

*The time to stability indicates the first day each clinical variable was stable according to the specified criterion. A variable was considered stable if all measurements over the 24-hour period met stability criteria. The Kaplain-Meier estimates of time to stability are for the subgroup of patients with a specified abnormality on admission. The day of admission is day 1. The stable oxygenation is oxygen saturation at least equal to the specified value or Pao_2 ≥60 mm Hg.
†N = 686.
‡N = 684.
§N = 611.
‖Eating status was stable if patients were able to eat (or resumed chronic enteral feeding). Stable mental status indicated a return to normal (or baseline) mental function.
¶N = 685.

gram-negative rods, and 16 (2%) with atypical organisms (*Legionella* species, *Mycoplasma pneumoniae*, and *Chlamydia pneumoniae*).

Vital Signs on Admission and Time to Stability

The average vital signs on admission were temperature of 37.7° ± 1°C; HR, 100 ± 19 beats/min; SBP, 134 ± 29 mm Hg; RR, 24 ± 6 breaths/min; and oxygen saturation, 92% ± 6%. Only 7 patients (1%) had an initial admission temperature 35°C or below, and 9 (1%) had a temperature of at least 40°C (104°F).

Among the 385 patients with HRs of more than 100 beats/min on admission, the median time to stabilization (HR ≤100 beats/min) was 2 days. Among the 7% patients with SBP lower than 90 mm Hg on presentation, the median time to stablize (SBP ≥90 mm Hg) was also 2 days. Similarly, among patients admitted with abnormalities in RR, oxygen saturation, and temperature, the median time to stablize RR (≤24 breaths/min), oxygen saturation (≥90%), and temperature (≤37.2°C [99°F]) was 3 days (Table 2). By day 4, over 75% of all HR, SBP, and RR abnormalities had been resolved (Figure 1). The time course of resolution of fever depended on the criterion for stable temperature (Figure 2). Over 75% of patients admitted with a fever had a stable temperature by day 3, when stability was defined as maximal temperature of the day of 38.3°C or less (101°F). However, according to the most conservative definition (highest temperature of the day ≤37.2°C [99°F]), stability was not reached by 75% of patients until day 6. Among the 8% of patients who were admitted with an acute change in mental status, the median time to return to baseline mental status was 3 days. Among patients who were unable to eat on admission (or were ordered not to eat by their physicians), the median time to being able to eat was 2 days. The time to stability of other functional status measures was also rapid (stable bladder and bowel function: median, 1 day; abililty to ambulate: median, 2 days).

The time to overall clinical stability, defined as normalization of all 5 vital signs, ability to eat, and mental status, also varied depending on the specific definition considered (Table 3). For the least conservative definition (A: temperature ≤38.3°C [101°F], HR ≤100 beats/min, SBP ≥90 mm Hg, RR ≤24 breaths/min, and oxygen saturation ≥90% or Pao_2 ≥60 mm Hg), the median time to overall stability among all patients was 3 days. Lowering the temperature threshold to 37.8°C [100°F] yielded a similar estimate of 3 days to stability. However, definitions based on more conservative criteria for stable temperature, oxygenation, and RR yielded median estimates of time to clinical stability of 5 to 7 days.

Patients with more severe pneumonia at presentation (classes IV and V) took longer to reach overall clinical stability compared with patients in classes I through III for all definitions of stability (Table 3; $P<.001$). There were no significant differences in the time to stability among PSI classes I, II, and III for all definitions. The differences in time to stability among the lowest- and highest-risk patients were greatest when stability was defined conservatively (definitions D and E; $P<.001$).

Adverse Events After Reaching Stability

The proportion of vital sign abnormalities occurring after the initial day of stability (eg, a temperature spike) varied depending on the individual vital sign and specific threshold used. Proportions that relapsed were 4% for SBP, 12% for HR, 17% for RR (≤24 breaths/min), 9% for oxygen saturation (≥90%), 1% for ability to eat, and 2% for mental status. Recurrence of fever occurred in 6% of patients for temperature above 38.3°C (101°F), 12% for temperature above 37.8°C (100°F), and 26% for temperature above 37.2°C (99°F). Fever (defined as temperature above 38.3°C [101°F]) developed in 2% of patients the day after stability, and in less than 1% of subjects on subsequent hospital days. Relapses in overall stability (a significant change in at least 1 variable) occurred in 25% of patients according to definition A and 45% of cases for the most conservative definition E. Small, transient fluctuations in RR were the most common cause of these changes. Relapses were much less likely to occur 2 and 3 days after stability (occurring 10%-15% and 4%-6% of the time, respectively).

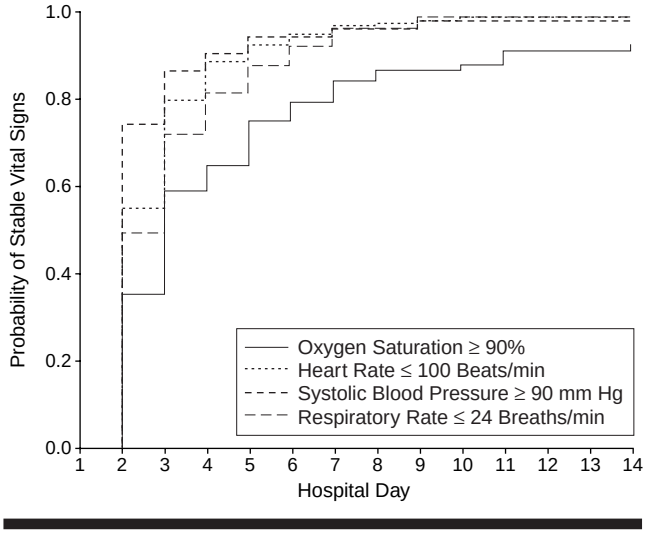

Figure 1.—Time needed to stabilize oxygen saturation, heart rate, respiratory rate, and systolic blood pressure in patients with abnormal vital signs on admission.

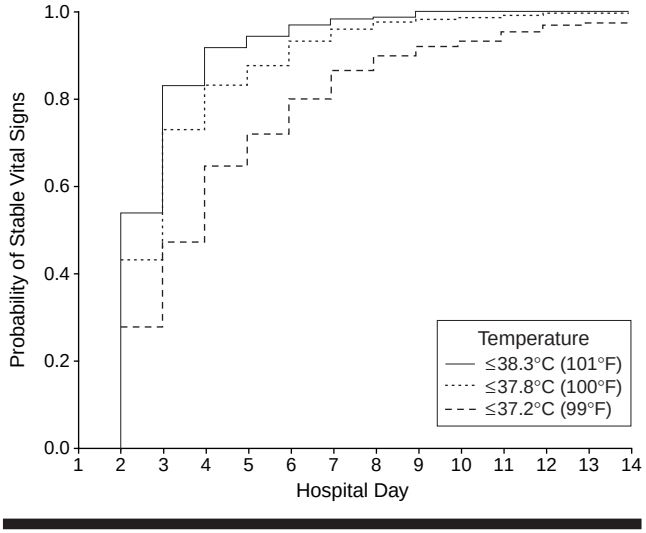

Figure 2.—Time needed to stabilize temperature in patients with fever on admission.

Table 3.—Effect of Different Definitions of Stability and Initial Disease Severity on Time to Overall Clinical Stability (N = 610)*

Definition of Stability				Pneumonia Severity Index Risk Class, d							
				Class I-III		Class IV		Class V		All Patients	
Definition	Temperature, ≥°C (°F)	0_2 Saturation, %	Respiratory Rate Breaths/min	Median	Interquartile Range	Median	Interquartile Range	Median	Interquartile Range	Median	Interquartile Range
A	≤38.3 (101)	≥90	≤24	3	2-4	3	2-7	5	3-9	3	2-5
B	≤37.8 (100)	≥90	≤24	3	2-5	4	2-7	6	3-9	3	2-6
C	≤37.2 (99)	≥92	≤24	4	3-7	6	3-9	7	4-11	5	3-8
D	≤37.2 (99)	≥92	≤20	6	3-12	7	3-16	10	6-17	6	4-13
E	≤37.2 (99)	≥94	≤20	6	4-15	9	4-17	13	7-17	7	4-17

*All definitions of stability include heart rate ≤100 beats/min, systolic blood pressure ≥90 mm Hg, ability to eat, and baseline mental status. The day of admission is day 1. For each definition, the time to stability is the first day that all 5 vital signs, ability to eat, and mental status were stable. The definition of stable oxygenation is oxygen saturation at least equal to the specified value or Pao_2 ≥60 mm Hg. Pneumonia Severity Index[14] risk classes I through III are low risk; class IV is moderate risk; and class V is high risk. Time to stability was longer for patients in classes IV and V compared with patients in classes I through III ($P<.001$). There were no differences between classes I, II, and III.

To evaluate the clinical significance of these relapses and further validate our model of stability, we examined the risk of major adverse events before and after stability. We chose SCU admissions as an indicator of serious medical instability. Ninety-one patients (15%) were admitted to an SCU during their hospital stay. Forty-five percent of these admissions were to an ICU, 45% to a TMU, and 10% to a CCU. The major reasons for admission were special care monitoring (55%), respiratory failure (34%), and hemodynamic instability (6%). Nearly two thirds of SCU admissions occurred on the day of admission and 15% on the day after admission.

Overall, 14% to 15% of patients were admitted to an SCU prior to stability (Table 4). As expected, patients in classes I through III had lower rates of admission to an SCU prior to stability (10%) than class IV (22%) and class V patients (24%, $P<.001$). However, for all risk classes and definitions considered, once a patient had stabilized, the risk of clinical deterioration serious enough to merit subsequent ICU, CCU or TMU admission was 1% or less. Even among the sickest subgroup of patients (class V), the absolute risk of needing an SCU after the day of stability was only 1%.

Hospital Course After Reaching Stability

The median hospital length of stay for the cohort was 6 days (IQR, 4-10 days; mean, 8.9±12.4 days). Regardless of the definition of stability used, the majority of patients stayed more than 1 day after reaching stability (Table 5). According to definitions A and B, which are modeled on commonly used guidelines, over 83% of patients stayed more than 1 day beyond clinical stability. These patients stayed in the hospital a median of 4 additional days after reaching stability. According to definition A, patients in class IV and class V had even longer hospital stays beyond stability compared with patients in classes I through III (4 vs 6 days, $P<.001$).

Overall, 648 patients (94%) were treated with parenteral antibiotic therapy within 24 hours of admission, most commonly macrolides (43%), second-generation cephalosporins (40%), aminopenicillins (21%), aminoglycosides (18%), and natural penicillins (14%). Among these 648 patients, the median day of discontinuing parenteral therapy was day 6 (IQR, 4-8). The median interval between reaching stability and discontinuation of parenteral antibiotic therapy (or conversion from parenteral to oral antibiotics) was 3 days according to definition A (IQR, 1-5) and 2 days for all other definitions (IQR, 1-4). The median time from discontinuation of parenteral therapy (or conversion to oral therapy) to discharge was 1 day (IQR, 1-3). Only 29% to 46% of patients in our study had parenteral antibiotic therapy discontinued or were converted from parenteral to oral therapy within 1 day of reaching clinical stability (Table 5).

COMMENT

Abnormalities in vital signs are common in patients with pneumonia and fre-

Table 4.—Risk of Admission to a Special Care Unit Before and After Reaching Stability*

Definition	Definition of Stability: Temperature, °C (°F)	Definition of Stability: O_2 Saturation, %	Definition of Stability: Respiratory Rate, Breaths/min	Admission to a Special Care Unit (N = 91): Before Stable, No. (%)	Admission to a Special Care Unit (N = 91): After Stable, No. (%)
A	≤38.3 (101)	≥90	≤24	85 (14)	6 (1)
B	≤37.8 (100)	≥90	≤24	85 (14)	6 (1)
C	≤37.2 (99)	≥92	≤24	87 (14)	4 (0.6)
D	≤37.2 (99)	≥92	≤20	88 (15)	3 (0.5)
E	≤37.2 (99)	≥94	≤20	89 (15)	2 (0.3)

*All definitions of vital sign stability include criteria of heart rate ≤100 beats/min, systolic blood pressure ≥90 mm Hg, ability to eat, and baseline mental status. Special care units include intensive care units, coronary care units, and telemetry monitoring units.

quently dictate the hospitalization decision.[20] Similarly, resolution of vital sign abnormalities are important determinants of the discharge decision.[9] Yet there are few studies of the time course of clinical recovery in this disease and no studies of a broad population of patients hospitalized with pneumonia. We found that vital signs, when considered individually, tend to stabilize within 2 or 3 days of hospitalization. The median time to stability of all vital signs and mental status abnormalities and regaining the ability to eat was 3 days according to most conventional definitions examined. However, when more conservative thresholds for temperature, RR, and oxygen saturation were used, the median time to stability lengthened to as many as 7 days. The time to stability was also significantly influenced by disease severity; patients with the most severe pneumonia at presentation took the longest to recover.

The risk of clinical deterioration serious enough to merit admission to an ICU, CCU, or TMU was greatest on the day of admission and dropped off dramatically thereafter. Ninety-three percent of all SCU admissions occurred prior to a full day of stability. Once overall stability was achieved, the risk of subsequent clinical deterioration serious enough to require SCU admission was 1% or less even among the sickest subgroup of patients.

Since relapses in stability, when they did occur, happened predominantly on the day after a patient gained stability, it might be reasonable to define potentially unnecessary hospital days as those more than 1 day beyond stability. Most of the patients we studied stayed in the hospital 3 to 4 days after reaching stability, suggesting ample opportunity to safely shorten length of stay. According to definition A (temperature, ≤38.3°C [101°F]; HR, ≤100 beats/min; SBP, ≥90 mm Hg; RR, ≤24 breaths/min; and oxygen saturation, ≥90%), which is based on commonly used guidelines, over 60% of total hospital days would have been considered potentially unnecessary.

Our findings are consistent with previous studies that reported the duration of fever in patients hospitalized with pneumonia due to *S pneumoniae* (mean, 2.8 days),[21] *H influenzae* (mean, 2.7 days),[21] *Legionella* species (range, 2.2-6 days),[22,23] and bacteremic pneumococcal pneumonia (mean, 3.1-6.7 days).[24-26] Our data corroborate the practice guideline developed by Weingarten and colleagues,[12,27] which used similar vital sign criteria and focused on hospital days 3 and 4 as the critical period for identifying low-risk patients with pneumonia who are stable and ready to be converted to oral antibiotics and discharged shortly thereafter. A recent report on 79 patients with pneumonia also reported a median 3 days to the resolution of morbidity (defined as temperature, ≤37.9°C [100.2°F]; RR, ≤24 breaths/min; oxygen saturation, ≥90%, and no worsening results on a chest x-ray film).[28]

For groups developing practice guidelines, critical pathways, or utilization review rules, our results should provide a more evidence-based estimate of achievable and appropriate length of stay. Guidelines and critical pathways, which often prespecify days that certain decisions should occur, have been criticized for their perceived "cookbook" or "one size fits all" approach.[29-31] We believe the explicit stability criteria we have developed provide a more clinically sensible way to define appropriateness for discharge for both individual patients and populations. However, because different definitions of stability can result in greater than 2-fold differences in the target length of stay, it is important that local groups reach consensus about which criteria are consonant with their own attitudes, beliefs, and risk tolerance.

These stability criteria have other implications for patient care decision making. Previous studies have suggested that early conversion from intravenous to oral antibiotics in patients with respiratory infections may be safe, effective, and shorten hospital length of stay.[32-37] In our cohort, only one third of patients were switched to oral antibiotics within 1 day of reaching stability. It seems reasonable to expect that once patients achieve stability they could be converted to oral antibiotics and discharged shortly thereafter in the absence of other active problems. In addition, information about the usual clinical course of patients with pneumonia should help providers identify patients who are not improving as expected, and thus may have complications (such as an empyema) or other underlying pulmonary processes that might require a change in management.

Our study has several strengths. Our cohort of patients was large and not restricted to a specific microbiologic etiology. The detailed, daily clinical information we collected enabled us to describe the clinical course of pneumonia in much greater detail than in any previous studies. Our findings are also less prone to institutional, geographical, or seasonal biases because we studied 4 hospitals in 3 geographical regions over a consecutive 30-month period.

However, there are several limitations worth noting. First, microbiological testing reflected usual clinical practice. As a result, the causative pathogen was unknown for most patients, and could not be easily factored into our as-

Table 5.—Hospital Course After Reaching Clinical Stability: Days Stayed and Conversion to Oral Antibiotics*

Definition	Definition of Stability: Temperature, °C (°F)	Definition of Stability: O_2 Saturation, %	Definition of Stability: Respiratory Rate, Breaths/min	Patients Who Stayed >1 Day After Stability, No. (%)	Days Stayed After Stability, Median (Interquartile Range)	Patients Converted to Oral Antibiotics Within 1 Day of Stability, No. (%)
A	≤38.3 (101)	≥90	≤24	428/497 (86)	4 (2-7)	125/436 (29)
B	≤37.8 (100)	≥90	≤24	406/489 (83)	4 (2-7)	147/422 (35)
C	≤37.2 (99)	≥92	≤24	326/423 (77)	3 (2-6)	136/340 (40)
D	≤37.2 (99)	≥92	≤20	238/362 (66)	3 (1-6)	119/260 (46)
E	≤37.2 (99)	≥94	≤20	198/304 (65)	3 (1-6)	93/212 (44)

*All definitions of vital sign stability include criteria of heart rate ≤100 beats/min, systolic blood pressure ≥90 mm Hg, ability to eat, and baseline mental status. Denominators vary due to differences in the number of patients who stabilized according to each definition and route of antibiotic therapy.

sessments. However, even in research studies that aggressively pursue etiology data, a definitive microbiologic diagnosis is lacking in 30% to 50% of cases.[17,38,39] Second, because many patients stayed in the hospital several days after reaching stability, we cannot know if they would have had a similarly benign course had they been discharged soon after becoming stable. Third, our model of stability may not fully take into account all important clinical factors dictating continued hospitalization. Active comorbid conditions would be factored into our assessments only if they affected the vital signs, ability to eat, and mental status. We found only a few cases in which delayed hospital discharge was due to nonclinical factors such as patient, family, and/or physician preferences, disagreement among physicians, delays in transfer to a nursing home or transportation home, or difficulties due to weekends or holidays.[40] Fourth, the relapse rates we present may overestimate the true rate since sicker patients tend to stay in the hospital longer and have more chances of having abnormal vital signs detected.[6-8] Finally, 2 issues regarding generalizability deserve comment. The patients we studied tended to be younger and less severely ill than the overall population of patients hospitalized with pneumonia. However, our analyses do account for the full spectrum of disease severity at presentation. Nevertheless, the extent to which our findings apply to groups that may have been underrepresented, such as the uninsured, nursing home residents, minorities, and the very old is unknown.

The median time to stability of vital signs and clinical status abnormalities in patients hospitalized with pneumonia was 3 days by most conventional definitions. Most patients appeared to stay several days beyond stability with low rates of late clinical deterioration, suggesting that average length of stay can be safely shortened. The use of objective criteria for stability should help providers and payers realize substantial cost savings by shortening unnecessarily long hospital stays. However, an explicit, discharge decision rule based on these models should be tested prospectively to ensure that a streamlined hospital course does not compromise patient outcomes.[30,31,41]

This research was part of the Pneumonia PORT Project funded by the Agency for Health Care Policy and Research grant R01 HS06468. The work was supported by National Research Services Award grant PE11001-08 (Dr Halm). Dr Fine is supported as a Robert Wood Johnson Foundation Generalist Physician Faculty Scholar.

We are indebted to Lin Hough, MPH, and Terry Sefcik, MS, for their data management assistance, John Orav, PhD, for his statistical advice, and Roslyn Stone, PhD, for her review of an earlier version of this article.

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